CONNECTICUT RIVER

NEW HAMPSHIRE, VERMONT,
CONNECTICUT AND MASSACHUSETTS

REVIEW OF REPORTS ON FLOOD CONTROL

APPENDIX - VOLUME I

SECTION 1 - HYDROLOGY & METEOROLOGY
SECTION 2 - FLOOD LOSSES - BENEFITS
SECTION 3 - POLLUTION
SECTION 4 - POWER & CONSERVATION

UNITED STATES ENGINEER OFFICE
PROVIDENCE, RHODE ISLAND
FEBRUARY 28, 1940

REVIEW OF REPORTS ON SURVEYS OF THE CONNECTICUT RIVER AND TRIBUTARIES FOR FLOOD CONTROL

APPENDIX

VOLUME I

UNITED STATES ENGINEER OFFICE

PROVIDENCE, RHODE ISLAND

FEBRUARY 28, 1940

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SECTION 1

HYDROLOGY AND METEOROLOGY

HYDROLOGY AND METEOROLOGY

SECTION 1

HYDROLOGY AND METEOROLOGY

General

1. SCOPE. - This section of the Appendix presents the hydrologic and meteorologic data pertinent to the flood of September 1938, and the results of studies based upon these data. It supplements Section I, "Hydrology and Meteorology", of the Appendix to the Report on Survey and Comprehensive Plan for Flood Control in the Connecticut River Valley, dated March 20, 1937, and printed in House Document No. 455, Seventy-fifth Congress, second session, hereinafter referred to as the 1937 Comprehensive Plan Appendix. The following section presents hydrologic data, and their sources, for the September 1938 flood; probable frequencies of peak flood discharges and flood volumes, revised upon the basis of the data furnished by the September 1938 flood; a description of refinements of the methods used in flood control analysis, including unit graphs, flood routing, and tributary and main-stem flood reducing effects of the reservoirs in the Revised Comprehensive Plan; and the considerations governing the determination of the sizes of spillways and outlets and the type of outlet control.

2. SOURCES OF HYDROLOGIC DATA. - Rainfall data for the storm of September 1938 were collected by the U. S. Weather Bureau, the U. S. Engineer Corps, the Massachusetts Department of Public Health, the New England Power Association, and numerous other public and private agencies. Records of stream run-off at eight stations on the Connecticut River and at 55 gaging stations on tributaries are available in publications of the Water Resources Branch of the U. S. Geological Survey. Stage records at several additional points in the Connecticut River Basin were obtained from other sources. Fifteen new stream gaging stations have been constructed in the Providence Engineer District by the U. S. Geological Survey with

funds made available by the U. S. Engineer Office at Providence. Nine of these stations are located in the Connecticut River Watershed. A recent canvass of all rainfall and stream gaging stations in the Providence District and vicinity has been made; the results are listed in Tables I and II, and the locations are shown on Plate No. 1.

3. HYDROLOGIC DATA FOR THE SEPTEMBER 1938 FLOOD. - The hydrology and history of the September 1938 flood are covered in the main report. Hourly graphs for the period September 17 to 21, 1938, inclusive, constructed from the records of 30 recording rain gages in and near the Connecticut River Basin are shown on Plates Nos. 2 and 3. The isohyetal map for the same period was prepared from all available rainfall records and is shown on Plate No. 4. Discharge hydrographs at eight gaging stations on the Connecticut River, and at 10 points on tributaries, for the period September 20 to 26, 1938, are shown on Plates Nos. 5 and 6. The volumes of run-off and peak discharges from these hydrographs are shown in Table III. High-water profiles for the flood of September 1938 on the Connecticut River below the Ascutney Bridge are shown on Plates Nos. 117 and 118, Section 8 of the Appendix. High-water marks on the Connecticut River above Ascutney Bridge and on the principal tributaries on which this flood was severe are shown on Plates Nos. 118, 119, 121, and 128 - 132, inclusive.

4. FREQUENCY RELATIONS. -

a. Peak discharge. - The probable frequency of peak discharges at each gaging station in the Connecticut River Watershed with a period of record longer than 5 years was determined by use of the prescribed frequency equation: $C = \frac{n}{m-0.5}$ in which C is the probable frequency of occurrence in years of a given value of discharge, m is the number of times during the period of record that the given discharge has been equalled or exceeded, and n is the number of years of record. Peak discharges determined from the original stage-recorder charts of the U. S.

TABLE I

EXISTING RAINFALL STATIONS IN PROVIDENCE DISTRICT AND VICINITY

NOTE: NUMBERS REFER TO NUMBERS ON PLATE NO. 1.

LEGEND: R DESIGNATES A RECORDING GAGE.
NR DESIGNATES A NON-RECORDING GAGE.

MAINE

No.	Station	Type	No.	Station	Type	No.	Station	Type
61	BETHEL	NR	4	FLAGSTAFF	NR	99	NO. BRIDGETON	NR
7	BIGLOW MT.	NR	89	GARDINER	NR	140	PORTLAND	R
10	BINGHAM	NR	122	HIRAM	NR	12	RANGELY	NR
2	CARATUNK	NR	101	LEWISTON	NR	49	RUMFORD	NR
72	E. WINTHROP	NR	26	MADISON	NR	1	THE FORKS	NR
3	EUSTIS	NR	30	MIDDLE DAM	NR	22	UPPER DAM	NR
36	FARMINGTON	NR	119	NAPLES	NR			

NEW HAMPSHIRE

No.	Station	Type	No.	Station	Type	No.	Station	Type
194	ALLENSTOWN	NR	189	GREAT FALLS	NR	176	NEWPORT	NR
100	BARTLETT	NR	247	GREENVILLE	NR	161	N. GRANTHAM	NR
54	BERLIN	NR	208	GREGGS FALLS	NR	31	N. STRATFORD	NR
77	BETHLEHEM	NR	216	HAMPTON	NR	230	PETERBORO	NR
186	BRADFORD	NR	138	HANOVER	R	87	PIERCE BRIDGE	NR
155	BRISTOL	NR	195	HILLSBORO	NR	83	PINKHAM NOTCH	NR
97	CANNON MT.	NR	203	JACKMAN FALLS	NR	11	PITTSBURG	R
174	CLAREMONT	NR	249	JEREMY HILL	NR	134	PLYMOUTH	NR
192	CONCORD	R	222	KEENE	NR	67	RANDOLPH	NR
25	DIXVILLE NOTCH	NR	162	LACONIA	NR	165	S. DANBURY	NR
197	DURHAM	NR	159	LAKEPORT	NR	179	SUNCOOK POND	NR
28	ERROL	NR	55	LANCASTER	NR	82	TWIN MT.	NR
214	EXETER	NR	95	LANDAFF	R	102	WEBSTER	NR
5	FIRST CONN. LAKE	NR	111	LINCOLN	NR	177	WENDELL	R
244	FITZWILLIAM	NR	211	MANCHESTER	R	146	W. CANAAN	NR
88	FRANCONIA	NR	202	MARLOW	NR	147	W. LEBANON	NR
168	FRANKLIN	NR	41	MILAN	NR	131	W. RUMNEY	NR
167	FRANKLIN FALLS	NR	236	MILFORD	NR	14	W. STEWARTSTOWN	NR
193	GARVINS FALLS	NR	225	MINNEWAWA	NR	235	W. WILTON	NR
172	GILMANTON IRON WORKS	NR	78	MT. WASHINGTON	NR	233	WILTON	NR
114	GLENCLIFF	NR	248	NASHUA	NR	243	WINCHESTER	R
66	GORHAM	NR	171	NEW DURHAM	NR	153	WOLFBORO FALLS	NR
						51	YORK POND	NR

VERMONT

No.	Station	Type	No.	Station	Type	No.	Station	Type
91	BARRE	NR	123	GOSHEN	NR	227	SEARSBURG STA.	NR
196	BELLOWS FALLS	NR	191	GRAFTON	R	215	SOMERSET	NR
228	BENNINGTON	NR	19	HIGHGATE FALLS	NR	105	S. NEWBURY	NR
125	BETHEL	NR	150	HYDEVILLE	NR	129	STOCKBRIDGE	R
27	BLOOMFIELD	R	70	MOLLYS FALLS	NR	166	TYSON	R
93	BOLTONVILLE	NR	251	MAYS MILL	NR	242	VERNON	NR
232	BRATTLEBORO	NR	85	MCINDOE FALLS	NR	68	WATERBURY	NR
52	BURLINGTON	R	108	MIDDLEBURY	NR	43	W. BURKE	NR
13	CANAAN	NR	75	MIDDLESEX	NR	63	W. DANVILLE	NR
175	CAVENDISH	NR	80	MONTPELIER	NR	135	W. HARTFORD	NR
115	CHELSEA	NR	212	NEWFANE	NR	45	WHEELOCK	NR
137	CHITTENDEN	NR	13	NEWPORT	NR	143	WHITE RIVER JCT.	NR
107	CORINTH	R	96	NORTHFIELD	R	238	WHITINGHAM	NR
116	CORNWALL	NR	120	N. TUNBRIDGE	NR	141	WILDER	NR
38	CRAFTSBURY COMMON	NR	158	PLYMOUTH	NR	231	WILMINGTON	NR
71	E. BARNET	NR	118	RANDOLPH CENTER	NR	164	WINDSOR	NR
37	E. HAVEN	NR	246	READSBORO	NR	148	WOODSTOCK	NR
90	E. RYEGATE	NR	86	RICKER MILLS	NR			
23	ENOSBURG FALLS	NR	121	ROCHESTER	NR			
50	ESSEX	NR	152	RUTLAND	NR			
46	GALLUP MILLS	NR	60	ST. JOHNSBURY	R			
62	GILMAN	NR	226	SEARSBURG MT.	NR			

TABLE I

EXISTING RAINFALL STATIONS IN PROVIDENCE DISTRICT AND VICINITY (CONT.)

NOTE: NUMBERS REFER TO NUMBERS ON PLATE NO. 1.

LEGEND: R DESIGNATES A RECORDING GAGE.
NR DESIGNATES A NON-RECORDING GAGE.

MASSACHUSETTS

NO.	STATION	TYPE	NO.	STATION	TYPE	NO.	STATION	TYPE
414	ACCORD	NR	317	HUBBARDSTON	NR	321	PRINCETON	NR
269	ADAMS	NR	543	HYANNIS	NR	446	PROVINCETOWN	NR
347	AMHERST	R	206	IPSWICH	NR	431	PROVIN MT. RES.	NR
387	ASHLAND	NR	365	JAMAICA PLAIN	NR	271	ROCKPORT	NR
264	ASHBY	NR	352	JEFFERSON	NR	346	RUTLAND	NR
410	ASHLEY POND	NR	356	KENDALL RES.	NR	309	SALEM	NR
292	ATHOL	NR	239	KENOZA LAKE	NR	285	SHELBURNE FALLS	NR
471	ATTLEBORO	NR	384	KETTLE BROOK NO. 3	NR	324	SHUTESBURY	NR
288	BALDWINSVILLE	NR	308	KNIGHTVILLE	NR	439	SOUTHBRIDGE	NR
330	BARRE	NR	364	LAKE COCHITUATE	NR	499	S. CARVER	NR
397	BEACHWOOD	NR	301	LAKE PLEASANT	NR	316	S. DEERFIELD	NR
406	BLANDFORD	NR	498	LAKEVILLE	NR	328	SPOT POND	NR
394	BLUE HILL	R	256	LAWRENCE	NR	427	SPRINGFIELD	R
399	BONDSVILLE	NR	305	LITTLETON	NR	473	STATE FARM	R
421	BORDEN BROOK RES.	NR	275	LOWELL	R	329	STERLING	NR
355	BOSTON	R	393	LUDLOW RES.	NR	370	STOCKBRIDGE	NR
345	BOYLSTON	NR	396	LYNDE BROOK	NR	367	SUDBURY DAM	NR
428	BRIMFIELD	R	322	LYNN	NR	318	SWAMPSCOTT	NR
436	BROCKTON	NR	296	MANCHESTER	NR	480	TAUNTON	NR
395	CARMODY RES.	NR	447	MANSFIELD	NR	590	TISBURY	NR
412	CHARLTON DEPOT	NR	542	MARSTONS MILLS	NR	280	TURNERS FALLS	NR
540	CHATHAM	NR	405	MCLEAN RES.	NR	441	UXBRIDGE	NR
369	CHESTER	NR	437	MENDON	R	342	WALTHAM	NR
337	CHESTERFIELD	NR	434	MIDDLEBORO	NR	381	WARE	NR
359	CHESTNUT HILL	NR	351	MIDDLEFIELD	NR	380	WARE CENT.	NR
332	CLINTON	NR	294	MIDDLETON	NR	334	WARE RIVER INTAKE	NR
268	COLRAIN	NR	400	MILLBURY	NR	398	WARREN	NR
326	CONCORD	NR	425	MILFORD	NR	261	WARWICK	NR
383	CORDAVILLE	NR	418	MILLIS	NR	344	WASHINGTON	R
320	CUMMINGTON	NR	252	MONROE BRIDGE	NR	445	WEBSTER	NR
314	DALTON	NR	435	MONSON	NR	302	WENDELL	NR
257	EAST NORTHFIELD	NR	290	MONTAGUE CITY	NR	295	WENHAM LAKE	NR
274	E. PEPPEREL	NR	401	MONTGOMERY	NR	391	W. BROOKFIELD	NR
419	E. WALPOLE	NR	312	MT. WACHUSETT	NR	426	WESTFIELD	NR
516	E. WAREHAM	NR	604	NANTUCKET	R	409	WESTFIELD DAM	NR
403	EGREMONT	NR	375	NEEDHAM	NR	423	WESTFIELD SANATORIUM	NR
336	EVERETT	NR	545	NEW BEDFORD	R	432	W. GRANVILLE	NR
536	FALL RIVER	NR	361	NEW BRAINTREE	NR	363	WESTHAMPTON	NR
564	FALMOUTH	NR	240	NEWBURYPORT	NR	341	WESTON	NR
298	FITCHBURG	NR	311	NEW SALEM	NR	402	W. OTIS	NR
378	FRAMINGHAM	NR	358	NEWTON	NR	422	W. PARISH	NR
442	FRANKLIN	NR	255	N. ANDOVER	NR	343	W. PELHAM	NR
273	FRYVILLE	NR	300	N. BEVERLY	NR	376	W. ROXBURY	NR
299	GARDNER	NR	420	NORTHBRIDGE	NR	353	W. RUTLAND	NR
348	GATES POND	NR	331	N. RUTLAND	NR	372	W. WARE	NR
284	GLOUCESTER	NR	468	NORTON	NR	373	WHITE RES.	NR
413	GREENBUSH	NR	407	NORWOOD	NR	389	WHITING STREET RES.	NR
293	GREENFIELD	NR	521	ONSET	NR	338	WILLIAMSBURG	NR
289	GROTON	NR	415	OTIS RES.	NR	254	WILLIAMSTOWN	NR
354	HARDWICK	NR	308	PEABODY	NR	319	WILLIAMSVILLE	NR
306	PETERSHAM –		443	PEMBROKE	NR	304	WILMINGTON	NR
	HARVARD FOREST	R	325	PERU	NR	267	WINCHENDON	NR
245	HAVERHILL	NR	313	PETERSHAM	NR	327	WINCHESTER	NR
262	HEATH	NR	303	PHILLIPSTON	NR	377	WOLLASTON	NR
366	HOLDEN NO. 2	NR	323	PITTSFIELD	NR	382	WORCESTER	R
400	HOLYOKE	NR	307	PLAINFIELD	NR	333	WORTHINGTON	NR
260	HOOSAC TUNNEL	NR	469	PLYMOUTH	NR	444	WRENTHAM	NR

TABLE I

EXISTING RAINFALL STATIONS IN PROVIDENCE DISTRICT AND VICINITY (Cont.)

Note: Numbers refer to numbers on Plate No. 1.

Legend: R designates a recording gage.
NR designates a non-recording gage.

CONNECTICUT

No.	Station	Type	No.	Station	Type	No.	Station	Type
595	Ansonia	NR	456	Enfield	R	594	N. Guilford	NR
494	Bakersville	NR	466	Falls Village	NR	617	N. Stamford	NR
549	Baltic	NR	530	Glastonbury	NR	489	N. Station	NR
496	Bloomfield	R	619	Greenwich	NR	618	Norwalk	NR
602	Branford	NR	546	Griswold	NR	569	Norwich	NR
613	Bridgeport	NR	597	Groton	NR	561	Pachaug Forest	R
539	Bristol	NR	512	Hartford	R	570	Prospect	NR
495	Browns Corner	NR	608	Hemlocks Res.	NR	479	Putnam	NR
537	Bulls Bridge	NR	550	Jewett City	NR	554	Rocky River	NR
508	Burlington	R	592	Lake Dawson	NR	452	Salisbury	NR
557	Camp Buck	NR	586	Lake Konomoc	NR	544	Shuttle Meadow	NR
461	Camp Connor	NR	601	Lake Saltonstall	NR	523	S. Meadows	R
488	Camp Cross	NR	593	Lake Whitney	NR	567	Squantz Pd.	NR
493	Camp Fernow	NR	615	Laurel Res.	NR	587	Stevenson Dam	NR
579	Camp Filley	NR	510	Manchester	NR	503	Storrs	R
605	Camp Hadley	NR	612	Mead Pond Res.	NR	453	Thompsonville	NR
449	Camp Robinson	NR	560	Middletown	NR	502	Torrington	NR
492	Camp Tourney	NR	610	Milford	NR	606	Trap Falls Res.	NR
475	Camp White	NR	568	Moodus	R	580	Wallingford	NR
571	Candlewood Isle	R	585	Mt. Carmel	NR	559	Waterbury	R
609	Cannondale	NR	573	Naugatuck	NR	603	Wepawaug Res.	NR
555	Colchester	NR	541	New Britain	R	513	W. Hartford	R
500	Collinsville	NR	482	New Hartford	NR	448	W. Hartland	NR
476	Cream Hill	NR	600	New Haven	R	487	West Hill	NR
589	Danbury	NR	533	Newington	R	519	Whigville Res.	NR
598	Derby	NR	506	New London	NR	528	Wigwam Res.	NR
470	E. Granby	NR	552	New Milford	NR	611	Wilton	NR
451	E. Hartland	NR	455	Norfolk	NR	491	Windsor	NR
607	Easton Lake	NR	599	N. Branford	NR	553	Wolcott Res.	NR
478	Ellington	R	460	N. Grosvernor Dale	NR	527	Woodville	R

RHODE ISLAND

No.	Station	Type	No.	Station	Type	No.	Station	Type
616	Block Island	R	576	Kingston	NR	505	Providence	R
464	Diamond Hill Res.	NR	504	Neutaconkanut Hill	NR	490	Rocky Hill	NR
525	Fiskeville	NR	574	Newport	NR	566	Slocum	NR
578	Fort Adams	R	497	N. Scituate	NR	526	Warren	NR
486	Greenville	NR	463	N. Smithfield	NR	535	Westcott	NR
501	Hopkins Mills	NR	485	Pawtucket	NR	591	Westerly	NR
517	Kent	NR	551	Portsmouth	NR	584	Wood River Jct.	NR
						459	Woonsocket	R

NEW YORK

No.	Station	Type	No.	Station	Type	No.	Station	Type
258	Albany	R	47	Harkness	NR	199	Schuylerville	NR
56	Ausable Forks	NR	220	Johnsonville	NR	621	Setauket	NR
112	Blue Ridge	NR	224	Mechanicsville	NR	176	Smiths Basin	NR
33	Cadyville	NR	462	Millerton	R	188	Spier Falls	NR
581	Carmel	NR	187	Mt. McGregor	NR	219	Stillwater Res.	NR
21	Chazy	NR	44	Peru	NR	163	Warrensburg	NR
620	Cutchogue	NR	103	Port Henry	NR	156	Whitehall	NR
29	Dannemora	NR	223	Schaghticoke	NR	64	Willsboro	NR
181	Glens Falls	NR	124	Schroon Lake	NR			

TABLE II

EXISTING U. S. GEOLOGICAL SURVEY STREAM GAGING STATIONS IN PROVIDENCE DISTRICT AND VICINITY

NOTE: NUMBERS REFER TO NUMBERS ON PLATE NO. 1.

LEGEND: R DESIGNATES WATER-STAGE RECORDER.
S " STAFF GAGE.
F " FLOAT GAGE.
C " CHAIN GAGE.
V " VENTURI METER.
P " RECORD FURNISHED BY PRIVATE AGENCY.

NO.	RIVER	LOCATION	TYPE	GROSS DRAINAGE AREA
		CONNECTICUT RIVER BASIN		
6	CONNECTICUT	FIRST CONNECTICUT LAKE, N. H.	R	83.0
32	"	NORTH STRATFORD, N. H.	R	796
59	"	NEAR DALTON, N. H.	R	1538
106	"	SOUTH NEWBURY, VT.	R	2825
142	"	WHITE RIVER JUNCTION, VT.	R	4068
287	"	TURNERS FALLS, MASS.	S(P)	7138
297	"	MONTAGUE CITY, MASS.	R	7840
454	"	THOMPSONVILLE, CONN.	R	9637
40	PASSUMPSIC	EAST HAVEN, VT.	R	48
69	"	PASSUMPSIC, VT.	R	423
58	MOOSE	ST. JOHNSBURY, VT.	R	126
73	STEVENS	BELOW HARVEY LAKE, VT.	R	22.2
81	AMMONOOSUC	BETHLEHEM JCT., N. H.	R	89.3
98	"	NEAR BATH, N. H.	R	395
110	SOUTH BRANCH OF WAITS	NEAR BRADFORD, VT.	R	45 APPROX.
130	WHITE	NEAR BETHEL, VT.	R	241
136	"	WEST HARTFORD, VT.	R	690
117	AYERS BROOK	RANDOLPH, VT.	R	30.5
145	MASCOMA	NEAR WEST CANAAN, N. H.	R	80.5
144	"	MASCOMA, N. H.	R	153
154	OTTAUQUECHEE	NORTH HARTLAND, VT.	R	221
173	SUGAR	WEST CLAREMONT, N. H.	R	269
180	BLACK	NORTH SPRINGFIELD, VT.	R	158
200	SAXTONS	SAXTONS RIVER, VT.	R	77 APPROX.
209	WEST	NEWFANE, VT.	R	308
207	ASHUELOT	NEAR GILSUM, N. H.	R	71.1
241	"	HINSDALE, N. H.	R	420
213	OTTER BROOK	NEAR KEENE, N. H.	R	41.8
229	SO. BRANCH OF ASHUELOT	WEBB, N. H.	R	36.6
259	MILLERS	NEAR WINCHENDON, MASS.	R	83.8
281	"	SOUTH ROYALSTON, MASS.	R	186.2
291	"	ERVING, MASS.	R	370
253	SIP POND BROOK	NEAR WINCHENDON, MASS.	R	19.0
263	PRIEST BROOK	NEAR WINCHENDON, MASS.	R	18.8
278	EAST BRANCH OF TULLY	NEAR ATHOL, MASS.	S	49.9
286	MOSS BROOK	WENDELL DEPOT, MASS.	S	12.2
279	DEERFIELD	CHARLEMONT, MASS.	R	362
272	NORTH	SHATTUCKVILLE, MASS.	R	89 APPROX.
357	MILL	NORTHAMPTON, MASS.	R	52 APPROX.
416	CHICOPEE	BIRCHAM BEND, MASS.	R	703
379	SWIFT	WEST WARE, MASS.	R	186
339	EAST BRANCH OF SWIFT	NEAR DANA, MASS.	R	43.7
340	WARE	COLD BROOK, MASS.	R(P)	96.8
390	"	GIBBS CROSSING, MASS.	R	199
411	QUABOAG	WEST BRIMFIELD, MASS.	R	151
362	WESTFIELD	KNIGHTVILLE, MASS.	R	162
430	"	NEAR WESTFIELD, MASS.	R	497
374	MIDDLE BRANCH OF WESTFIELD	GOSS HEIGHTS, MASS.	R	52.6

TABLE II (CONTINUED)

NO.	RIVER	LOCATION	TYPE	GROSS DRAINAGE AREA
		CONNECTICUT RIVER BASIN (CONTINUED)		
386	WEST BRANCH OF WESTFIELD	HUNTINGTON, MASS.	R	93.7
429	WESTFIELD LITTLE	OUTLET OF COBBLE MOUNTAIN RES. NEAR WESTFIELD, MASS.	V(P)	45.8
434	MILL	SPRINGFIELD, MASS.	R	36 APPROX.
483	SCANTIC	BROAD BROOK, CONN.	R	98.4
432	FARMINGTON	NEAR NEW BOSTON, MASS.	R	92.0
467	"	RIVERTON, CONN.	R	216
477	"	TARIFFVILLE, CONN.	R	578
506	BURLINGTON BROOK	NEAR BURLINGTON, CONN.	R	4.1
511	PARK	HARTFORD, CONN.	R	74.0
514	SOUTH BRANCH OF PARK	HARTFORD, CONN.	R	40.6
507	NORTH BRANCH OF PARK	HARTFORD, CONN.	R	25.3
509	HOCKANUM	NEAR EAST HARTFORD, CONN.	R	74.5
562	SALMON	NEAR EAST HAMPTON, CONN.	R	105
583	EAST BRANCH OF EIGHT MILE	NEAR NORTH LYME, CONN.	R	22.0
582	WEST BRANCH OF EIGHT MILE	NEAR NORTH LYME, CONN.	S	19.2
		THAMES RIVER BASIN		
531	SHETUCKET	NEAR WILLIMANTIC, CONN.	R	401
515	WILLIMANTIC	NEAR SOUTH COVENTRY, CONN.	R	121
524	HOP	NEAR COLUMBIA, CONN.	R	76.2
522	NATCHAUG	WILLIMANTIC, CONN.	R	169
438	QUINEBAUG	WESTVILLE, MASS.	R	93.8
450	"	QUINEBAUG, CONN.	R	157
481	"	PUTNAM, CONN.	R	331
556	"	JEWETT CITY, CONN.	R	711
424	LITTLE	BUFFUMVILLE, MASS.	R	27.7
534	MOOSUP	MOOSUP, CONN.	R	83.5
563	YANTIC	YANTIC, CONN.	R	88.6
		HOUSATONIC RIVER BASIN		
315	HOUSATONIC	COLTSVILLE, MASS.	R	57.1
385	"	NEAR GREAT BARRINGTON, MASS.	R	280
465	"	FALLS VILLAGE, CONN.	R	632
588	"	STEVENSON, CONN.	R	1545
538	TENMILE	NEAR GAYLORDSVILLE, CONN.	R	204
565	STILL	NEAR LANESVILLE, CONN.	R	68.5
518	SHEPAUG	WOODVILLE, CONN.	P	38.0
558	"	NEAR ROXBURY, CONN.	R	133
572	POMPERAUG	SOUTHBURY, CONN.	R	75.3
529	NAUGATUCK	NEAR THOMASTON, CONN.	R	71.9
575	"	NEAR NAUGATUCK, CONN.	R	246
532	LEADMINE BROOK	NEAR THOMASTON, CONN.	R	24.0
		BLACKSTONE RIVER BASIN		
392	BLACKSTONE	WORCESTER, MASS.	R	31.3
417	"	NORTHBRIDGE, MASS.	R	137 APPROX.
458	"	WOONSOCKET, R. I.	R	416
404	QUINSIGAMOND	GRAFTON, MASS.	R	35 APPROX.
440	MUMFORD	E. DOUGLAS, MASS.	R	27.8
457	BRANCH	FORESTDALE, R. I.	R	94 APPROX.
		PAWTUXET RIVER BASIN		
520	PAWTUXET	CRANSTON, R. I.	R	201 APPROX.
		QUINNIPIAC RIVER BASIN		
548	QUINNIPIAC	SOUTHINGTON, CONN.	C	17.6
577	"	WALLINGFORD, CONN.	R	109
547	EIGHT MILE	PLANTSVILLE, CONN.	S	14.9

TABLE II (CONTINUED)

NO.	RIVER	LOCATION	TYPE	GROSS DRAINAGE AREA
		SAUGATUCK RIVER BASIN		
614	SAUGATUCK	NEAR WESTPORT, CONN.	R	77.5
		TAUNTON RIVER BASIN		
474	TAUNTON	STATE FARM, MASS.	R	260
472	WADING	NEAR NORTON, MASS.	R	42.4
		HUDSON RIVER BASIN		
206	BATTEN KILL	ARLINGTON, VT.	C	152
201	" "	BATTENVILLE, N. Y.	R	394
283	HOOSIC	ADAMS, MASS.	R	46.3
218	"	NEAR EAGLE BRIDGE, N. Y.	R	510
255	NORTH BRANCH OF HOOSIC	NORTH ADAMS, MASS.	R	39.0
221	WALLOOMSAC	NEAR NORTH BENNINGTON, VT.	R	111
237	MOHAWK	COHOES, N. Y.	R	3456
250	POESTEN KILL	NEAR TROY, N. Y.	R	89
350	KINDERHOOK CREEK	ROSSMAN, N. Y.	R	329
		CHARLES RIVER BASIN		
349	CHARLES	WALTHAM, MASS.	R	248
388	MOTHER BROOK	DEDHAM, MASS.	F	
		IPSWICH RIVER BASIN		
277	IPSWICH	NEAR IPSWICH, MASS.	R	124
		MERRIMACK RIVER BASIN		
170	MERRIMACK	FRANKLIN JCT., N. H.	R	1507
210	"	MANCHESTER, N. H.	S(P)	2854
217	"	NEAR GOFFS FALLS, N. H.	R	3092
276	"	LOWELL, MASS.	R	4635
104	E. BR. OF PEMIGEWASSET	NEAR LINCOLN, N. H.	R	104
133	PEMIGEWASSET	PLYMOUTH, N. H.	R	622
132	BAKERS	NEAR RUMNEY, N. H.	R	143
157	SMITH	NEAR BRISTOL, N. H.	R	85.8
160	LAKE WINNIPESAUKEE	LAKEPORT, N. H.	F(P)	363
169	WINNIPESAUKEE	TILTON, N. H.	R	471
185	CONTOOCOOK	PENACOOK, N. H.	R	766
205	NO. BRANCH OF CONTOOCOOK	NEAR ANTRIM, N. H.	F	54.8
184	BLACKWATER	NEAR WEBSTER, N. H.	R	129
190	SUNCOOK	NO. CHICESTER, N. H.	R	157
234	SOUHEGAN	MERRIMACK, N. H.	R	171
270	NORTH NASHUA	EAST PEPPERELL, MASS.	R	433
310	" "	NEAR LEOMINSTER, MASS.	R	107
335	SO. BRANCH OF NASHUA	CLINTON, MASS.	V(P)	107.7
282	CONCORD	LOWELL, MASS.	R	405
371	SUDBURY	FRAMINGHAM CENTER, MASS.	V(P)	75.2
360	LAKE COCHITUATE	COCHITUATE, MASS.	V(P)	17.4
		PISCATAQUA RIVER BASIN		
183	SALMON FALLS	NEAR SOUTH LEBANON, ME.	R	147
204	LAMPREY	NEAR NEWMARKET, N. H.	R	183
198	OYSTER	NEAR DURHAM, N. H.	R	12.1
		SACO RIVER BASIN		
113	SACO	NEAR CONWAY, N. H.	R	386
128	"	CORNISH, ME.	R	1298
139	"	W. BUXTON, ME.	S(P)	1572
126	OSSIPEE	CORNISH, ME.	R	453

TABLE II (CONTINUED)

NO.	RIVER	LOCATION	TYPE	GROSS DRAINAGE AREA
		PRESUMPSCOT RIVER BASIN		
127	PRESUMPSCOT	SEARGO LAKE, ME.	S(P)	436
		ANDROSCOGGIN RIVER BASIN		
57	ANDROSCOGGIN	NEAR GORHAM, N. H.	R	1390
48	"	RUMFORD, ME.	R(P)	2090
102	"	NEAR AUBURN, ME.	R	3257
20	MAGALLOWAY	AZISCOHOS DAM, ME.	S(P)	233
39	SWIFT	NEAR ROXBURY, ME.	R	95
84	LITTLE ANDROSCOGGIN	NEAR SOUTH PARIS, ME.	R	76.2
		KENNEBEC RIVER BASIN		
9	KENNEBEC	BINGHAM, ME.	R	2710
8	AUSTIN STREAM	BINGHAM, ME.	R	92
24	CARRABASSETT	NEAR NORTH ANSON, ME.	R	351
34	SANDY	NEAR MERCER, ME.	R	514
		ST. LAWRENCE RIVER BASIN		
149	POULTNEY	BELOW FAIR HAVEN, VT.	R	187
151	OTTER CREEK	CENTER RUTLAND, VT.	R	307
109	" "	MIDDLEBURY, VT.	R	628
79	WINOOSKI	MONTPELIER, VT.	R	433
53	"	NEAR ESSEX JUNCTION, VT.	R	1079
94	JAIL BRANCH	EAST BARRE, VT.	R	33.0
74	NORTH BRANCH OF WINOOSKI	WRIGHTSVILLE, VT.	R	69.2
92	DOG	NORTHFIELD FALLS, VT.	R	76.1
76	MAD	NEAR MORETOWN, VT.	R	139
65	WATERBURY	NEAR WATERBURY, VT.	R	111
42	LAMOILLE	JOHNSON, VT.	R	335
35	"	NEAR MILTON, VT.	R	723
15	MISSISQUOI	NEAR NORTH TROY, VT.	R	131
17	"	NEAR RICHFORD, VT.	R	479
16	CLYDE	NEWPORT, VT.	R	140

Table III

VOLUME AND PEAK DISCHARGES OF FLOODS OF NOVEMBER 1927, MARCH 1936, AND SEPTEMBER 1938

River	Station	Drainage Area Square Miles	1927 Rainfall Inches	1927 Run-off Inches	1927 Peak Discharge C.F.S.	1936 Rainfall Inches	1936 Run-off From Rain Inches	1936 Run-off From Snow Inches	1936 Run-off Total Inches	1936 Peak Discharge C.F.S.	1938 Rainfall Inches	1938 Run-off Inches	1938 Peak Discharge C.F.S.
Connecticut	Dalton	1,538				4.40	4.40	2.71	7.11	48,300			19,600
Connecticut	Waterford	1,603	5.25	3.00	30,200								
Connecticut	Comerford Dam	1,650							7.23	55,000	4.00	2.21	20,000
Passumpsic	Passumpsic	423	5.69	4.10	25,200	3.23	3.12	4.08	7.20	16,000	3.75	1.95	7,710
Wells	Mouth	99	6.51	5.15		3.66	3.66	4.30	7.96	5,300	4.50	2.86	4,600
Ammonoosuc	Bath	393	5.78	4.92	37,600	4.10	3.60	4.89	8.49	27,900	5.80	3.99	26,800
	Reach #1 Local	372				3.66	3.66	3.22	6.88	-			
	Reach #1 Local	307	5.63	4.15	-								
	Reach #1 Local	260									5.20	2.88	-
Connecticut	South Newbury	2,325	5.19	3.64	65,900	3.95	3.95	3.71	7.66	77,800	4.20	2.50	43,700
Waits	Mouth	156	6.74	5.05		3.77	3.77	4.00	7.77	8,000	4.65	3.24	6,800
Ompompanoosuc	Mouth	136	7.07	5.44		3.77	3.77	4.07	7.84	7,400	5.35	3.25	5,800
White	West Hartford	690	7.01	6.20	70,300	2.59	2.59	5.62	8.21	45,400	4.60	3.62	47,600
	Reach #2 Local	261	6.55	4.80	-	3.77			4.73	-	4.80	3.24	-
Connecticut	White River Jc.	4,068	5.84	4.26	136,000	3.68	3.68	3.68	7.36	120,000	4.40	2.78	82,400
Mascoma	Mascoma	153	6.25	2.37	3,230	3.85	3.85	3.02	6.87	5,840	7.20	3.74	4,400
Ottauquechee	North Hartland	221	7.49	5.92	30,400	3.48	3.45	5.65	9.10	19,200	6.30	5.24	24,400
Sugar	West Claremont	269	4.75	2.53	9,400	3.62	3.62	3.61	7.23	14,000	7.50	4.63	13,100
Black	North Springfield	158	7.85	6.37	20,500	3.74	3.74	4.76	8.50	14,700	7.15	4.31	15,500
	Reach #3 Local	518	5.80	3.80	-	3.87	3.87	3.33	7.20	-	6.90	4.31	-
Connecticut	Bellows Falls	5,387	5.93		150,500				7.45	175,000	5.00	3.17	115,500
Saxtons	Mouth	78	6.57	4.77		4.94	4.94	2.98	7.92	5,000	7.20	4.39	5,600
West	Newfane	308	8.60	7.35	53,100	4.64	4.64	4.85	9.49	39,000	7.50	6.44	52,300
	Reach #4 Local	467	5.18	3.03	-				7.30	-	7.60	4.69	-
Connecticut	Vernon	6,240	6.02	4.28	159,000	3.85	3.85	3.45	7.30	182,000	5.40	3.46	132,500
Ashuelot	Hinsdale	420	4.94	2.70	6,700	4.26	4.26	4.15	8.41	16,600	8.60	5.91	16,200
Millers	Erving	370	4.68	2.55	5,600	4.85	4.85	4.20	9.05	19,700	12.00	8.68	29,000
Deerfield	Charlemont	362	7.50	3.83	16,800	4.72	4.72	2.31	7.03	32,200	8.80	6.05	56,300
	Reach #5 Local	448	4.41	2.21	-	4.53	4.53	2.80	7.33	-	9.60	5.11	-
Connecticut	Montague City	7,840	5.92	3.95	188,000	3.98	3.98	3.54	7.52	236,000	6.30	4.05	195,000
Chicopee	Bircham Bend	703	4.17	2.00	-	5.41	5.41	0.64	6.05	20,400	12.40	7.69	45,200
Westfield	Westfield	497	6.16	4.72	42,500	4.83	4.83	1.72	6.55	48,200	10.00	5.88	55,500
	Reach #6 Local	597	4.67	2.59	-	4.05	4.05	5.52	9.57	-	10.80	3.43	-
Connecticut	Thompsonville	9,637	5.74		190,000	4.40	4.40	3.02	7.42	282,000	7.20	4.35	236,000
Scantic	Broad Brook	98	3.46	1.48		4.24			3.24	1,620	12.80	5.18	7,360
Farmington	Tariffville	578	5.98	4.02		3.97	3.97	1.28	5.25	22,200	10.80	4.47	29,900
	Reach #7 Local	167	3.75	1.66	-	3.17				-	11.50	5.78	-
Connecticut	Hartford	10,480			181,000				6.66	291,000	7.50	4.39	251,000

Geological Survey offices at Boston, Massachusetts, and Hartford, Connecticut, were plotted against their probable frequency of occurrence and a smooth curve drawn through them. Curves of frequency thus determined are shown on Plates Nos. 7, 8, and 9. Discharges at various parameters of frequency were read from each frequency curve, divided by the drainage area at the station, and plotted to form a relation between frequency of instantaneous peak discharge and drainage area. It was found that the parameters of frequency fell into four smooth alinements. The areas included in each alinement were:

(1) The entire main stem of the Connecticut River.

(2) Tributaries west of the Connecticut River and south of the Ompompanoosuc River, and the Ammonoosuc River.

(3) Connecticut River tributaries in New Hampshire south of the Ammonoosuc River.

(4) Tributaries east of the Connecticut River and south of the New Hampshire - Massachusetts State line.

The peak discharges for a given frequency, shown on Plate No. 9, are in some cases higher and in some cases lower than the values shown in the 1937 Comprehensive Plan Appendix.

b. Volume. - The relations of flood volume to frequency, for all gaging stations for which data were available, were determined by following the procedure outlined in the paragraph above; and the general relations of flood volume, in inches of depth on each drainage area, to the drainage area as the other variable were determined for various parameters of frequency. The volume of a given flood was taken as the total discharge from the beginning of rise to the end of the flood period. The relations of flood volume to frequency, established from actual records, and shown in the 1937 Comprehensive Plan Appendix, were considered satisfactory for use in studies for this report.

5. METHODS USED IN FLOOD CONTROL ANALYSIS. - The methods of flood control analysis are explained in the section on Hydrology and Meteorology of the 1937 Comprehensive Plan Appendix. No changes in the basic methods of analysis were made for this report.

a. Unit graphs. - The unit graphs were determined in general as described in the 1937 Comprehensive Plan Appendix, and modified to allow for infiltration. This varies from the method previously used, in that infiltration at a constant rate, rather than a constant percentage of the rainfall, is deducted from the rainfall to determine the run-off.

b. Flood routing. -

(1) General. - In certain cases it was found necessary to revise the flood routing coefficients "K" and "x". The revised values are shown in Table IV.

(2) Agreement between experienced and reconstituted flood of September 1938. - Discharge hydrographs at the limits of each Connecticut River routing reach were computed for the flood of September 1938 by continuous routing from the uppermost reach, and were then compared, as shown on Plate No. 5, with the hydrographs determined from stage records and rating curves. An even closer agreement could be obtained for any particular reach by routing the experienced inflow hydrograph, rather than the computed inflow hydrograph, to the lower end of the reach. In the application of the method to produce hypothetical floods and to determine reservoir effects, however, the continuous routing procedure must be used. In order to make the modified hydrographs and the experienced hydrographs of record comparable, all computed modified hydrographs were adjusted by the discharge differentials between computed and experienced hydrographs.

TABLE IV FLOOD ROUTING REACHES AND BASIC DATA - CONNECTICUT RIVER WATERSHED

NO.	TRIBUTARY	REACH		DRAINAGE AREA	MILES ABOVE OUTFLOW STATION	X	T (IN DAYS)	K	C_0	C_1	C_2
		INFLOW STATION	OUTFLOW STATION								
1	COMERFORD DAM	-	SOUTH NEWBURY	1,650	28.1	.4	.5	1.04	-.19	.765	.425
	PASSUMPSIC	PASSUMPSIC	"	423	30.5	.0	.5	1.06	.19	.19	.62
	WELLS	MOUTH	"	99	13.0	.0	.5	.98	.22	.22	.56
	AMMONOOSUC	BATH	"	393	18.1	.3	.5	.91	-.026	.59	.436
	LOCAL #1	-	"	260	0.0	--	--	--	--	--	--
2	SOUTH NEWBURY	-	WHITE R. JCT.	2,825	37.8	.4	.5	.55	.05	.82	.13
	WAITS	MOUTH	"	156	31.7	.3	.5	.38	.27	.71	.02
	OMPOMPANOOSUC	MOUTH	"	136	9.2	.3	.5	.04	--	--	--
	WHITE	W. HARTFORD	"	690	7.5	.3	.5	--	--	--	--
	LOCAL #2	-	"	261	0.0	--	--	--	--	--	--
3	WHITE RIVER JCT.	-	BELLOWS FALLS	4,068	41.6	.3	.5	.53	.14	.66	.20
	MASCOMA	MASCOMA	"	153	50.6	.3	.5	.61	.105	.635	.260
	OTTAUQUECHEE	N. HARTLAND	"	221	38.0	.3	.5	.50	.165	.665	.170
	SUGAR	W. CLAREMONT	"	269	24.1	.3	.5	.42	.235	.693	.072
	BLACK	N. SPRINGFIELD	"	158	17.7	.3	.5	.38	.27	.71	.02
	LOCAL #3	-	"	518	0.0	--	--	--	--	--	--
4	BELLOWS FALLS	-	VERNON	5,387	31.7	.3	.5	.48	.18	.67	.15
	SAXTONS	MOUTH	"	78	30.6	.0	.5	.48	.34	.34	.32
	WEST	NEWFANE	"	308	20.0	.0	.5	.26	.50	.50	.00
	LOCAL #4	-	"	467	0.0	--	--	--	--	--	--
5	VERNON	-	MONTAGUE CITY	6,240	22.9	.3	.5	.38	.27	.71	.02
	ASHUELOT	HINSDALE	"	420	22.2	.0	.5	.38	.40	.40	.20
	MILLERS	ERVING	"	370	14.8	.3	.5	.25	.41	.765	-.175
	DEERFIELD	CHARLEMONT	"	362	20.3	.3	.5	.16	.56	.82	-.38
	LOCAL #5	-	"	448	0.0	--	--	--	--	--	--
6	MONTAGUE CITY	-	THOMPSONVILLE	7,840	51.1	.3	.5	.64	.08	.63	.29
	CHICOPEE	BIRCHAM BEND	"	703	17.4	.0	.5	.36	.41	.41	.18
	WESTFIELD	WESTFIELD	"	497	14.8	.0	.5	.37	.40	.40	.20
	LOCAL #6	-	"	597	0.0	--	--	--	--	--	--
7	THOMPSONVILLE	-	HARTFORD	9,637	16.0	.0	.5	.28	.47	.47	.06
	SCANTIC	BROAD BROOK	"	98	13.2	.0	.5	.11	.69	.69	-.38
	FARMINGTON	TARIFFVILLE	"	578	17.5	.0	.5	.31	.45	.45	.10
	LOCAL #7	-	"	167	0.0	--	--	--	--	--	--
8	HARTFORD	MEMORIAL BRIDGE	"	10,480	0.0	--	--	--	--	--	--
	PARK	MOUTH	"	74	0.0	--	--	--	--	--	--
	HOCKANUM	EAST HARTFORD	"	75	4.6	--	--	--	--	--	--
	LOCAL #7A	-	"	14	0.0	--	--	--	--	--	--
	HARTFORD	LOWER	"	10,643	0.0	--	--	--	--	--	--

c. Reductions at points on the main stem.

(1) General. - The method used is that described in the 1937 Comprehensive Plan Appendix. The computations have been revised to include data obtained from the flood of September 1938. A refinement in the method of determining modified discharges and stages on tributaries was accomplished by an improvement in the value of the exponent "p", as described in the following paragraph. The determination of modified discharges and stages on the Connecticut River was accomplished by routing all inflow hydrographs, modified by reservoir storage, through the natural valley storage. The modified Connecticut River stages and discharges are given in Tables XI and XII of the main report, and the modified hydrographs are shown on Plate No. 5.

(2) Percent reductions. - The indices of the reduction, by individual reservoirs, of peak discharge at Connecticut River index stations were computed as described in the 1937 Comprehensive Plan Appendix. The indices given in that Appendix were computed for two floods, that of March 1936 and an 8-inch demonstration flood, and averaged. The indices shown in Table V were computed from three floods, i.e., the two mentioned above and that of September 1938, and averaged.

d. Tributary reductions. - Modified peak discharges for all tributary index stations were computed by the following formula:

$$Q_m = \left[\frac{A - \frac{(aLv)}{V}}{A}\right]^p Q_n = \left[1 - \frac{aLv}{AV}\right]^p Q_n$$

in which

Q_m = modified peak discharge at index station in cubic feet per second,

Q_n = natural peak discharge at index station in cubic feet per second,

a = drainage area at the dam site, in square miles,

TABLE V INDICES OF RELATIVE REDUCTIONS OF PEAK DISCHARGE AT CONNECTICUT RIVER INDEX STATIONS BY INDIVIDUAL RESERVOIRS.

RESERVOIR	RIVER	RESERVOIR CAPACITY INCHES OF RUN-OFF	INDEX STATION		S. NEW.	WILLER.	W.R.JC.	B. FALLS	VERNON	MON.CY.	THOMPS.	HARTFORD
			ZONE NO.		1	2	3	4	5 & 6	7	8 & 9	10
			REACH NO.		1	1-A	2	3	4	5	6	7
			DRAINAGE AREA		2825	3378	4068	5337	6240	7840	9637	10643
			GROSS	NET								
					STORAGE RESERVOIRS COMPLETED IN 1939.							
PITTSBURG	CONNECTICUT		172		5.53	3.83	2.36	1.38	.39	.74	.61	.62
WINSOR	CHICOPEE (SWIFT)		186								2.32	2.11
BARKHAMSTED	FARMINGTON (EAST BRANCH)		53									.67
					REVISED COMPREHENSIVE PLAN OF RESERVOIRS.							
UPPER FIFTEEN MILE FALLS	CONNECTICUT	5.5	1626		52.26	36.25	22.26	13.04	8.44	7.01	5.80	5.84
LYNDONVILLE	PASSUMPSIC	7.0	70		2.96	2.41	1.83	1.19	.77	.59	.45	.43
VICTORY	" (MOOSE)	8.0	66		2.79	2.27	1.73	1.12	.73	.56	.42	.40
SUGAR HILL	AMMONOOSUC	7.0	246		12.41	10.42	7.29	4.66	2.97	2.22	1.67	1.54
SOUTH BRANCH	WAITS (SOUTH BRANCH)	7.0	45			1.46	1.69	1.25	.93	.71	.54	.48
UNION VILLAGE	OMPOMPANOOSUC	4.5	126			3.36	4.27	3.46	2.91	2.22	1.67	1.52
GAYSVILLE	WHITE	7.0	226				8.78	6.09	4.57	3.45	2.54	2.27
AYERS BROOK	" (AYERS BROOK)	7.0	30				1.17	.81	.61	.46	.34	.30
SOUTH RANDOLPH	" (SECOND BRANCH)	7.0	63				2.45	1.70	1.27	.96	.71	.63
SOUTH TUNBRIDGE	" (FIRST BRANCH)	6.0	102				3.96	2.75	2.06	1.56	1.15	1.03
WEST CANAAN	MASCOMA	8.0	88				2.33	1.57	1.08	.81	.59	.55
NORTH HARTLAND	OTTAUQUECHEE	6.0	222				9.16	6.93	5.13	3.83	2.79	2.46
CLAREMONT	SUGAR	6.0	245					6.55	4.99	3.77	2.81	2.55
LUDLOW	BLACK	8.0	56					1.44	1.33	.96	.76	.68
NORTH SPRINGFIELD*	"	6.2	158	102				2.63	2.43	1.74	1.37	1.24
BROCKWAY	WILLIAMS	6.0	101					2.33	2.39	1.88	1.52	1.33
CAMBRIDGEPORT	SAXTONS	7.0	58						1.16	.99	.86	.76
WILLIAMSVILLE	WEST	7.0	400						10.35	8.24	6.74	5.56
SURRY MOUNTAIN	ASHUELOT	6.1	100						1.79	1.39	1.08	.97
OTTER BROOK	" (OTTER BROOK)	7.0	47						.84	.65	.51	.46
HONEY HILL	" (SOUTH BRANCH)	7.0	70						1.25	.97	.76	.68
LOWER NAUKEAG	MILLERS	8.0	20							.32	.26	.23
BIRCH HILL*	"	6.0	175	155						2.47	1.99	1.76
TULLY	" (TULLY EAST BRANCH)	8.3	50							.79	.64	.57
FORT MORRISON	DEERFIELD (NORTH)	6.0	48							.70	.63	.57
EASTHAMPTON	MANHAN	6.0	68							1.02	.68	.65
BARRE FALLS	CHICOPEE (WARE)	8.0	57								.71	.65
WEST BROOKFIELD	" (QUABOAG)	6.0	106								1.33	1.20
KNIGHTVILLE	WESTFIELD	4.5	164								1.68	1.72
TOTALS				4749	70.42	56.17	66.97	57.52	58.00	50.27	43.00	39.03

* INDICES SHOWN ARE FOR NET DRAINAGE AREAS.
ALL VALUES SHOWN ARE PERCENTAGES.

A = drainage area at index station, in square miles,

v = flood volume above dam site, in inches,

V = flood volume above index station, in inches,

L = ratio of reservoir capacity to flood volume above dam site,

p = exponent of drainage area relation necessary to show the effect of the controlled area above the index station on peak discharges at the index station. This exponent is dependent upon the physical characteristics of the controlled area as compared with those of the total area above the index station. It was found by investigation of available stream flow data that it should have a value between 0.75 and 1.0.

This method is based upon the assumption that the modified hydrograph at the dam site is proportional to the natural hydrograph. This assumption is well within the limits of error that result in applying a general formula. The ratio $\frac{v}{V}$ corrects for the difference between volume of run-off at the dam site and volume of run-off at the index point. The value L corrects for the inability to store the entire run-off at the dam site. When the flood volume is equal to or less than the reservoir capacity, L becomes equal to unity. For those cases where more than one reservoir is located above a tributary index point, the reduction of peak discharge was determined for each reservoir, separately, and these values were summated to obtain the total reduction.

Hypothetical Floods

6. DESIGN FLOOD.

a. General. - A design flood for the entire Connecticut River Watershed was necessary, upon which to base a study of the effectiveness of the combination of reservoirs and levees of the Revised Comprehensive Plan. Once the rainfall characteristics of the hypothetical storm producing the design flood have been selected, the unit graph and flood routing methods outlined in paragraph 5 can be applied to determine the run-off characteristics, the reductions by reservoirs, and, finally, the height of protection required of the levees. This design flood should be more severe than any of record, and yet should have a reasonable probability of occurrence. An extensive study of the storm which produced the flood of September 1938 resulted in the adoption of the following features of that storm, modified, as a reasonable basis for a design flood:

(1) The intensity and approximate distribution of the total rainfall, as defined by the isohyets.

(2) The duration of the storm.

(3) The relation between time and total depth of rainfall for the area.

b. Depth and duration of rainfall. - The storm of September 1938 was the most severe of record in New England. It is possible that a similar storm of at least equal severity but of different geographical location could occur. Consequently, the isohyetal map defining the storm of September 1938 was superimposed over the Connecticut River Watershed and reoriented in a manner to produce the greatest volume over the entire area, and, at the same time, to place the heaviest rainfall over the greatest flood-producing area. The hypothetical isohyetal map, with the isohyets in the reoriented position, is shown on Plate No. 10. The rainfall depths shown by these reoriented isohyets were used to define the design storm. The duration of the storm of September 1938 was generally 96 hours, with intermittent periods of heavy intensity. The duration of the design flood storm was selected as 72 hours, resulting in more severe conditions by concentrating the rainfall in a shorter period of time.

c. Intensities. - Values from the maximum 6-, 12-, and 96-hour isohyetal maps of the storm of September 1938 determined three area-depth curves. For a drainage area of 10,000 square miles, approximately that at Hartford, an intensity-duration curve was obtained by plotting a value from each area-depth curve, with the value from the 96-hour area-depth curve being plotted at 72 hours. Because of the large size of the drainage area, it was not necessary to considered rainfall periods shorter than 12 hours. Studies have shown that the Connecticut River Watershed above Hartford produces the greatest flood peaks when the rain graph has its maximum value shortly after the mid-point of the storm period. Consequently the maximum 12-hour intensity of the design storm was placed immediately following the mid-point of the storm period, i.e., between the 36th and 48th hours. The second greatest 12-hour depth was placed in the period between the 24th and 36th hours, the third greatest in the period between the 48th and 60th hours, etc.

d. Infiltration. - An infiltration rate of .05 inch per hour was assumed. This is the minimum to be expected over a large area for a storm of great magnitude occurring over an extended period of time. This infiltration rate, in effect for the entire storm duration, results in an over-all run-off of 64 percent of the rainfall, at Hartford.

e. Composition of design flood. - Unit graphs had previously been determined for selected local areas upstream from the points along the main stem where design flood hydrographs were desired. These unit graphs were obtained by the method described in the 1937 Comprehensive Plan Appendix, and are based upon unit graphs determined at all the stream gaging stations of the U. S. Geological Survey in the Connecticut River Watershed. For each of the selected component areas, the total volume of rainfall for the design storm was determined by taking the average depth of the re-oriented isohyets over each area. The intensity of rainfall for each component area was made to conform to the intensity-duration relation and distribution described in c, above, and then applied to the unit graphs, with an infiltration rate of .05 inch per hour. The resulting discharge hydrographs were routed to Montague City, Northampton, Holyoke, Chicopee, Springfield, and Hartford.

f. Summary. - The discharge hydrographs for the design flood at Holyoke, Springfield, and Hartford are shown on Plate No. 11. A comparison between the design flood and the greatest flood of record is given in Table VI.

TABLE VI

COMPARISON OF DESIGN FLOOD AND MAXIMUM FLOOD OF RECORD

Station	Drainage area sq.mi.	Design Flood				Maximum Flood of Record			
		Volume of run-off		Peak Discharge		Volume of run-off		Peak Discharge	
		inches	1,000 ac.-ft.	c.f.s.	c.f.s. per sq. mi.	inches	1,000 ac.-ft.	c.f.s.	c.f.s. per sq.mi.
Montague City	7,840	5.63	2,350	338,000	43.2	7.55	3,160	236,000	30.1
Northampton	8,010	5.68	2,430	341,500	42.6	7.15	3,060	239,000	29.8
Holyoke	8,284	5.77	2,540	356,000	43.0	7.19	3,180	244,000	29.5
Chicopee	9,030	5.95	2,860	405,000	44.9	7.06	3,400	267,000	29.5
Springfield	9,587	6.08	3,110	417,500	43.5	7.04	3,600	281,000	29.3
Hartford	10,643	6.03	3,420	420,000	39.5	6.83	3,870	291,000	27.3

7. DEMONSTRATION FLOOD. - Inasmuch as the design flood storm rainfall is unevenly distributed, it was desired to establish a demonstration flood having a uniform run-off volume over the entire watershed and a peak discharge at Hartford equal to that of the design flood. The run-off volume of the demonstration flood, for all points, is seven inches. The rainfall is assumed to occur in 72 hours, with the maximum intensity

occurring from the 36th to the 48th hours. This volume and intensity were applied to the unit graph for each index area, and the resultant hydrographs were routed to Montague City, Northampton, Holyoke, Chicopee, Springfield, and Hartford. The hydrographs for the demonstration flood at Holyoke, Springfield, and Hartford are shown on Plate No. 11. A comparison of peak discharges for the floods of March 1936, September 1938, the Design Flood, and the Demonstration Flood is given in Tables XI and XII of the main report.

Spillways

8. SPILLWAY REQUIREMENTS. - Each of the spillways for the reservoirs shall have sufficient capacity to pass the respective spillway design flood, with no possibility of overtopping the dam even under the following adverse conditions:

- a. The reservoir filled to spillway crest at the beginning of the spillway design flood.
- b. The outlet gates closed.
- c. The outlet gates inoperative or the outlet passages blocked during the entire flood period.
- d. The maximum wave height occurring at the instant of maximum spillway discharge.

9. SPILLWAY DESIGN FLOOD. - Spillway design floods for all reservoirs studied in the Connecticut River Watershed are based upon the following conditions:

- a. The use of unit graphs derived from floods of record at existing gaging stations where the drainage area of the gaging station is within 10 percent of the drainage area at the dam site; otherwise the unit graphs were taken from the Connecticut River empirical relations as described in the 1937 Comprehensive Plan Appendix.

b. A rainfall volume and distribution as recently determined by the Office of the Chief of Engineers and based upon a recent study of rainfall in New England.

c. A rainfall duration of 24 hours.

d. An infiltration rate of 0.05 inch per hour.

e. A factor of safety of 1.25 to 1.50 applied to the computed flood.

The computed floods, without the factors of safety, result from the worst possible storm magnitude, intensity, distribution, rate of infiltration, and watershed run-off conditions. Because of the smaller maximum rainfall rates to be expected in winter, the computed floods described are more severe than the corresponding computed winter floods, including run-off from melting snow. The factors of safety for each reservoir vary from 1.25 to 1.50, depending upon the accuracy of the hydrologic data.

10. SPILLWAY DESIGN DISCHARGE. - It was assumed that the spillway design flood for each reservoir occurred with the reservoir filled to spillway crest and the outlets blocked with debris, or closed, during the entire flood period. It was also assumed that the effect of surcharge storage would offset the valley storage in all cases. The resulting spillway design discharges are shown in Table VII.

11. SURCHARGE. - The surcharge selected for each reservoir is that for which the total cost of the dam and reservoir is a minimum. In some cases this was slightly modified because of construction difficulties. The surcharges are shown in Table VII.

12. FREEBOARD. - The design freeboard is the difference in elevation between the top of the dam and the water surface at maximum surcharge. For earth dams its selection is a function of the maximum wave height and ride-up, wind set-up, and the depth of frost action. Maximum wave heights are determined by the Stevenson-Molitor formula:

TABLE VII

SPILLWAY DATA AND CHARACTERISTICS FOR CONNECTICUT RIVER FLOOD CONTROL DAMS

NO.	RESERVOIR	RIVER	GROSS DRAINAGE AREA SQ.MI.	FLOOD CONTROL CAPACITY INCHES OF R.O.	ELEVATIONS FEET ABOVE MSL SPILLWAY CREST	ELEVATIONS FEET ABOVE MSL TOP OF DAM	TYPE	LOCATION	DISCHARGE COEFFICIENT	DESIGN DISCHARGE C.F.S.	SURCHARGE FEET	CREST LENGTH FEET
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	MASSACHUSETTS											
1	KNIGHTVILLE	WESTFIELD	164	4.5	600.0	630.0	GRAVITY SECTION OVERFLOW	IN RIGHT ABUTMENT	3.8	87,500	15.0	400
2	EASTHAMPTON	MANHAN	68	6.0	167.0	182.0	GRAVITY SECTION OVERFLOW	IN RIGHT ABUTMENT	3.9	33,000	10.0	270
3	FORT MORRISON	DEERFIELD (NORTH)	48	6.0	711.0	728.0	SIDE-CHANNEL	IN LEFT ABUTMENT	3.8	62,000	12.0	400
4	WEST BROOKFIELD	CHICOPEE (QUABOAG)	106	6.0	611.5	626.0	GRAVITY WALL SECTION	IN RIVER CHANNEL	– △	31,000	–	430
5	BARRE FALLS	CHICOPEE (WARE)	57	8.0	815.5	832.5	BROAD-CRESTED WEIR	IN RIGHT ABUTMENT	3.0	33,000	12.0	265
6	TULLY	MILLERS (TULLY EAST BRANCH)	50	8.3	668.0	685.0	OVERFLOW WEIR	IN SADDLE SOUTHEAST OF DAM	3.7	28,800	10.0	255
7	BIRCH HILL	MILLERS	155*	6.0	852.0	864.0	OVERFLOW WEIRS	IN SADDLES ON RIGHT ABUTMENT	3.3	57,000	7.0	920
8	LOWER NAUKEAG	MILLERS	20	8.0	1075.5	1085.5	GRAVITY SECTION OVERFLOW	IN RIVER CHANNEL & LEFT ABUTMENT	3.9	13,000	5.0	300
	NEW HAMPSHIRE											
9	HONEY HILL	ASHUELOT (SOUTH BRANCH)	70	7.0	520.0	535.0	OVERFLOW WEIR	IN RIGHT ABUTMENT	3.9	34,000	10.0	280
10	OTTER BROOK	ASHUELOT (OTTER BROOK)	47	7.0	771.5	786.5	OVERFLOW WEIR	IN RIGHT ABUTMENT	3.6	25,000	10.0	220
11	SURRY MOUNTAIN	ASHUELOT	100	6.1	550.0	565.0	SIDE-CHANNEL	IN RIGHT ABUTMENT	3.8	40,900	10.0	337
12	CLAREMONT	SUGAR	245	6.0	627.5	642.5	SIDE-CHANNEL	IN LEFT ABUTMENT	3.8	88,000	10.0	740
13	WEST CANAAN	MASCOMA	80	8.0	910.0	927.0	BROAD-CRESTED WEIR	IN RIGHT ABUTMENT	3.0	34,000	12.0	275
14	SUGAR HILL	AMMONOOSUC	246	7.0	739.0	759.0	OVERFLOW WEIR	IN RIGHT ABUTMENT	3.9	86,000	15.0	380
15	UPPER FIFTEEN MILE FALLS	CONNECTICUT	1626	5.5	851.0	376.0	BROAD-CRESTED WEIR	IN LEFT ABUTMENT	3.0	202,000	20.0	755
	VERMONT											
16	WILLIAMSVILLE	WEST	400	7.0	478.0	499.0	SIDE-CHANNEL	IN RIGHT ABUTMENT	3.8	140,000	16.0	580
17	CAMBRIDGEPORT	SAXTONS	58	7.0	642.0	657.0	SIDE-CHANNEL	IN LEFT ABUTMENT	3.8	42,[illegible]	10.0	350
18	BROCKWAY	WILLIAMS	101	6.0	552.5	567.5	OVERFLOW WEIR	IN LEFT ABUTMENT	3.9	50,500	10.0	410
19	NORTH SPRINGFIELD	BLACK	102*	6.2	528.5	547.5	GRAVITY SECTION OVERFLOW	IN RIGHT ABUTMENT	3.9	84,000	14.0	415
20	LUDLOW	BLACK	56	8.0	1096.0	1111.0	SIDE-CHANNEL	IN RIGHT ABUTMENT	3.8	42,000	16.0	175
21	NORTH HARTLAND	OTTAUQUECHEE	222	6.0	546.5	563.5	SIDE-CHANNEL	IN LEFT ABUTMENT	3.8	102,000	12.0	650
22	SOUTH TUNBRIDGE	WHITE (FIRST BRANCH)	102	6.0	564.0	585.0	SIDE-CHANNEL	IN LEFT ABUTMENT	3.8	73,000	16.0	300
23	SOUTH RANDOLPH	WHITE (SECOND BRANCH)	63	7.0	596.5	616.5	BROAD-CRESTED WEIR	IN LEFT ABUTMENT	3.0	47,000	15.0	270
24	AYERS BROOK	WHITE (AYERS BROOK)	30	7.0	697.5	712.5	SIDE-CHANNEL	IN RIGHT ABUTMENT	3.8	16,000	10.0	135
25	GAYSVILLE	WHITE	226	7.0	798.0	819.0	SIDE-HILL	IN RIGHT ABUTMENT	3.8	96,000	16.0	395
26	UNION VILLAGE	OMPOMPANOOSUC	126	4.5	554.0	584.0	BROAD-CRESTED WEIR	IN RIGHT ABUTMENT	3.0	52,000	13.0	370
27	SOUTH BRANCH	WAITS (SOUTH BRANCH)	45	7.0	815.0	833.0	SHAFT	IN RIGHT ABUTMENT	3.3	25,000	13.0	140‡
28	VICTORY	PASSUMPSIC (MOOSE)	66	8.0	1175.0	1192.0	OVERFLOW WEIR	IN RIGHT ABUTMENT	3.6	24,000	12.0	160
29	LYNDONVILLE	PASSUMPSIC	70	7.0	844.0	859.0	SIDE-CHANNEL	IN RIGHT ABUTMENT	3.8	44,000	10.0	365

△ CREST SUBMERGED AT 31,000 C.F.S.

* NET DRAINAGE AREA.

‡ EFFECTIVE CREST LENGTH.

$$h = 0.17\sqrt{V\ F} + 2.5 - \sqrt[4]{F}$$

in which h is the wave height in feet, V the wind velocity in miles per hour, and F the fetch in miles. Wave height plus ride-up is assumed at 1.4 times the wave height. Wind set-up S, in feet, is given by the formula

$$S = \frac{V^2\ F\ \cos\ A}{800\ D}$$

in which V and F are as above, D = depth in feet, and A = angle between direction of maximum fetch and wind. In the case of masonry dams where the safety of the structure is not dependent upon the surcharge and freeboard, the freeboard has been selected as less than 5 feet. The minimum design freeboard selected for each of the earth dams is 5 feet.

13. TYPES OF SPILLWAY. - Several types of spillway have been adopted in the design of the various dams, as dictated by topographic, geologic, and construction features. The type selected for each dam is given in Table VII.

Outlets

14. OUTLET REQUIREMENTS. - The outlets shall be suitably controlled by gates, and shall be of sufficient size to permit the following operations:

a. The partial storing and partial releasing of run-off during the outlet design flood, which is an hypothetical flood of very rare occurrence, in such a manner as to obtain the greatest flood reduction at downstream damage centers with a pool elevation not exceeding the spillway crest.

b. The discharging of local freshets that do not produce damage, without utilizing more than a minor portion of the flood control capacity.

c. The emptying of a major portion of a full reservoir within a few days.

d. The passing of possible minor floods during construction of the dam, with upstream levels that will not require excessive heights of cofferdams. Except during construction, the size of the outlet is not considered as affecting the safety of the dam against overtopping. No outlet discharge is assumed in determining the size of the spillway, and consequently it provides an additional factor of safety.

15. OUTLET DESIGN FLOOD. - The outlet design flood is an hypothetical flood with a volume equal to the volume of run-off of 100-year frequency on a stream of equal drainage area in New England. The flood hydrograph was computed from a 2-1/2-day rainfall, using the unit hydrograph method. The precipitation was assumed to occur at a constantly increasing rate during the first half of the storm, and a constantly decreasing rate during the second half. In general, the resulting peak discharge is somewhat higher than the highest peak discharge of record.

16. OUTLET DISCHARGE CAPACITY. - A basic "retarding basin discharge", such that with the outlet discharging freely the design flood just fills the reservoir to spillway crest, was determined by trial and error. This discharge was then increased by a factor to provide suitable flexibility of operation of the reservoir. The increased discharge capacity thus obtained is the required outlet discharge capacity.

17. FLEXIBILITY FACTORS. - The flexibility factors vary in order to provide flexibility of operation within the reservoir system to obtain the greatest flood reductions at downstream damage centers. In general, the nearer that a reservoir is located to a damage zone, the greater are the possibilities of passing the early part of any flood

through the outlets and conserving the storage capacity of the reservoir until its use would effect the greatest reduction of peak discharge at the damage center. From a study of dam-site flood hydrographs routed through the natural valley storage of the Connecticut River to the main damage centers, these factors were determined and are shown in Table VIII. The range of variation of this factor is 1.0 to 1.8, the larger value s applying to the tributaries nearer the mouth of the Connecticut River.

18. NUMBER AND SIZE OF OUTLETS. - The minimum requirement for the number of gates was set at two in order to permit practical operation throughout a wide range of types of flood. The required gate area was taken as approximately 20 percent in excess of the recommended outlet area, with an even greater margin where dictated by excessive velocities. The sizes and types of gates are shown in Table VIII, and were selected to meet the best standards and greatest economy in design.

19. PLAN OF OPERATION. - The reservoirs will be operated to secure the greatest possible benefit at main damage centers on the Connecticut River. The flood control capacities of the reservoirs will normally be kept empty. **Water will be stored** only when necessary to prevent damage at downstream points, on both the tributaries and the main river. A flood may be entirely retained if its total volume is insufficient to fill the reservoir. This will be possible for all but the greater floods. The operation is to be guided by observation of rainfall and stream flow as a flood progresses so as to determine at the earliest possible time whether a flood can be expected to attain so great a magnitude that it cannot be fully retained, and how large a discharge must be passed in order to utilize the entire flood control capacity of the reservoir without overflowing the spillway crest, and whether it is necessary to permit surcharge on the spillway to avoid synchronization of flood

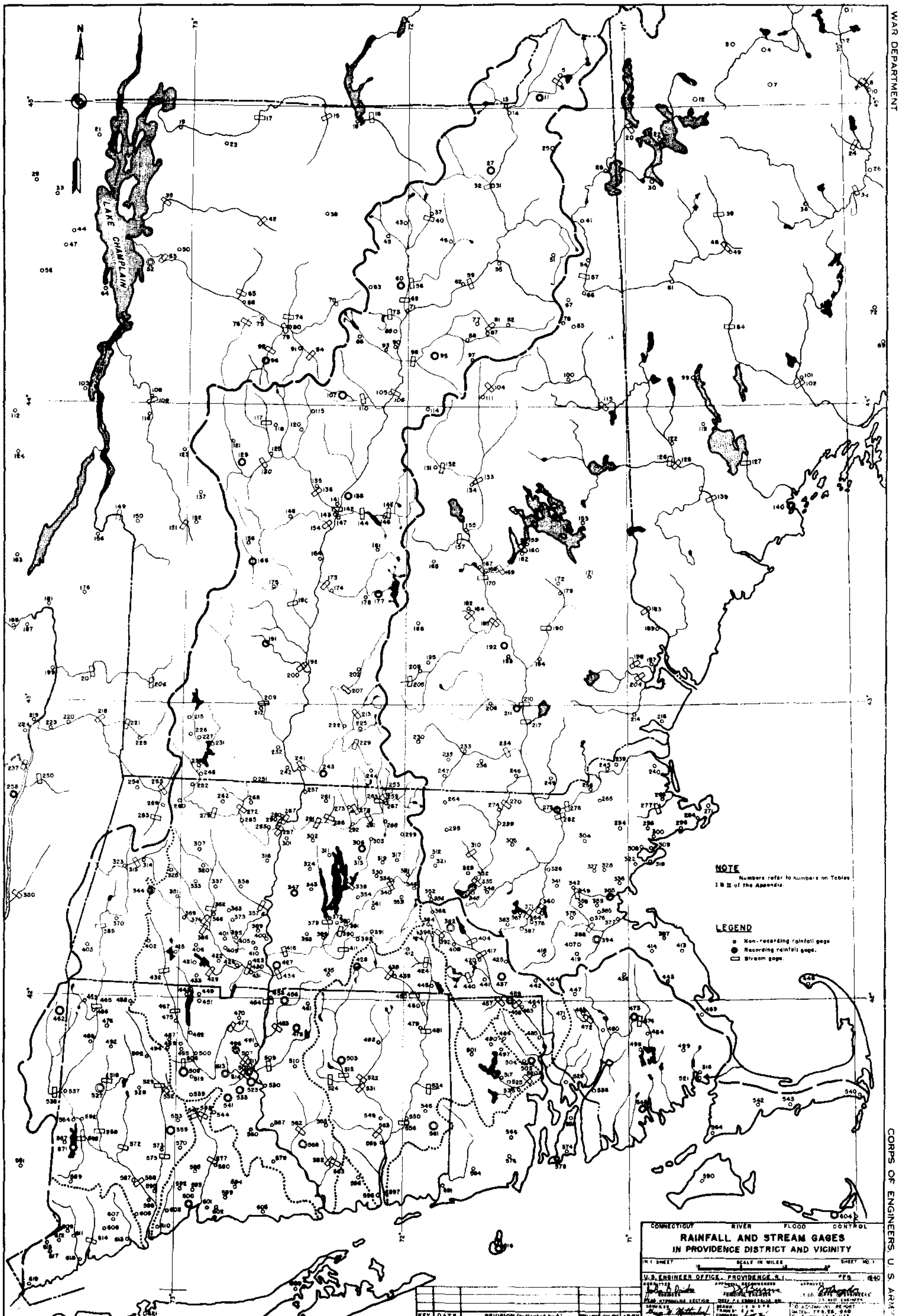
TABLE VIII

OUTLET DATA AND CHARACTERISTICS OF CONNECTICUT RIVER FLOOD CONTROL DAMS

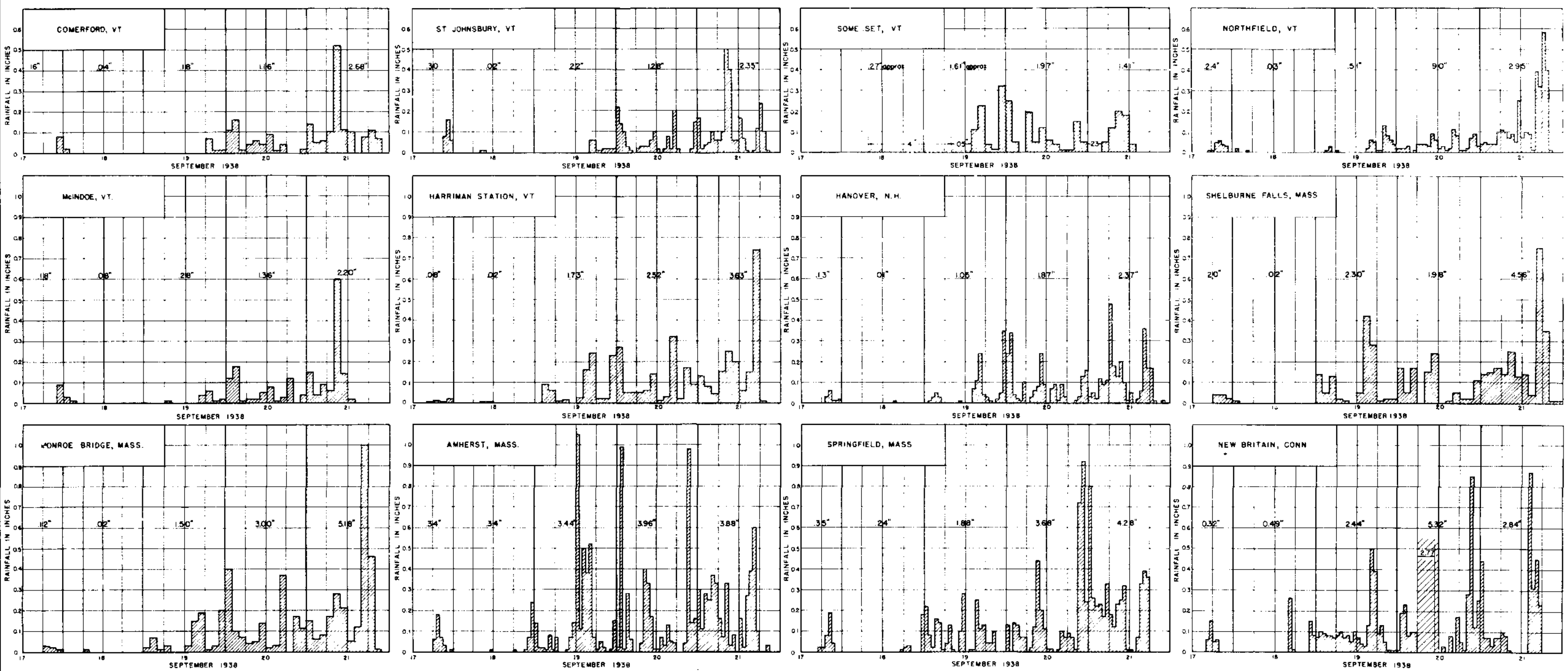
No.	Reservoir	River	Gross Drainage Area Sq. Mi.	Flood Control Capacity: Inches of R. O.	Elevations, Feet above M.S.L.: Spillway Crest	Elevations: Invert at Intake	Elevations: Invert at Exit	Elevations: Crown at Exit	Maximum Operating Head - Feet	Conduit Length - Feet	Loss in Terms of Velocity Head	Maximum Velocity - Feet per Second	Retarding Basin Discharge - C.F.S.	Factor of Flexibility	Design Discharge: C.F.S.	Design Discharge: C.F.S. per Sq. Mi.	Service Gates: Type	Service Gates: Number and Size	Conduit: Type	Conduit: Number and Size	Conduit: Area Sq. Ft.	Conduit: Maximum Discharge C.F.S.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
	MASSACHUSETTS																					
1	Knightville	Westfield	164	4.5	600.0	480.0	468.0	484.0	116.0	607	1.48	71.0	8,500	1.7	14,450	88	Broome	3-6.0'x12.0'	Circular	1-16.0' Diam.	201.1	14,300
2	Easthampton	Manhan	66	6.0	167.0	125.0	125.0	132.0	35.0	35	1.32	41.3	2,120	1.6	3,390	50	Sluice	3-4.0'x7.0'	Rectangular	3-4.0x7.0'	84.0	3,470
3	Fort Morrison	Deerfield (North)	48	6.0	711.0	617.0	615.0	627.0	84.0	550	1.89	53.4	2,170	1.5	3,260	68	Broome	3-5.0x9.0'	Horseshoe	1-12.0' Diam.	119.4	6,380
4	West Brookfield	Chicopee (Quaboag)	106	6.0	611.5	596.0	596.0	605.0	6.5	30	1.27	18.1	1,700	1.8	3,060	29	Truck	4-5.0'x9.0'	Rectangular	4-5.0'x9.0'	180.0	3,260
5	Barre Falls	Chicopee (Ware)	57	8.0	815.5	775.0	770.0	777.5	38.0	330	2.05	34.5	870	1.8	1,570	28	Sluice	2-3.5'x7.5'	Horseshoe	1-7.5' Diam.	46.6	1,610
6	Tully	Millers (Tully East Branch)	50	8.2	668.0	625.0	620.0	626.0	42.0	287	1.80	38.8	300	1.3	390	8	Sluice	2-3.5'x6.0'	Circular	1-6.0' Diam.	28.3	1,100
7	Birch Hill	Millers	155*	6.0	852.0	815.0	815.0	827.0	25.0	35	1.21	36.5	5,400	1.7	9,200	59	Truck	4-6.0'x12.0'	Rectangular	4-6.0'x12.0'	288.0	10,500
8	Lower Naukeag	Millers	20	8.0	1075.5	1057.0	1057.0	1063.0	12.5	25	1.31	24.8	350	1.4	490	25	Sluice	2-3.0x6.0'	Rectangular	2-3.0'x6.0'	36.0	890
	NEW HAMPSHIRE																					
9	Honey Hill	Ashuelot (South Branch)	70	7.0	520.0	472.0	471.0	481.0	39.0	365	1.79	37.5	1,600	1.3	2,080	30	Broome	2-5.0'x10.0'	Horseshoe	1-10.0' Diam.	82.9	3,100
10	Otter Brook	Ashuelot (Otter Brook)	47	7.0	771.5	672.0	660.0	666.0	105.5	700	3.32	45.2	1,060	1.3	1,380	29	Sluice	2-3.0'x6.0'	Horseshoe	1-6.0' Diam.	29.9	1,360
11	Surry Mountain	Ashuelot	100	6.1	550.0	485.0	434.0	494.0	56.0	383	1.86	44.0	2,300	1.2	2,760	28	Broome	2-4.5'x10.0'	Horseshoe	1-10.0' Diam.	82.9	3,650
12	Claremont	Sugar	245	6.0	627.5	522.0	522.0	536.0	91.5	660	1.96	54.8	5,500	1.3	7,150	29	Broome	3-6.5'x10.0'	Horseshoe	1-14.0' Diam.	162.5	8,900
13	West Canaan	Mascoma	80	8.0	910.0	855.0	850.0	860.0	50.0	360	1.78	42.5	900	1.2	1,080	14	Broome	2-5.0'x10.0'	Horseshoe	1-10.0' Diam.	82.9	3,520
14	Sugar Hill	Ammonoosuc	246	7.0	739.0	600.0	600.0	612.0	127.0	1250	2.81	53.9	3,500	1.1	3,850	16	Broome	3-5.0'x9.0'	Horseshoe	1-12.0' Diam.	119.4	6,440
15	Upper Fifteen Mile Falls	Connecticut	1626	5.5	851.0	645.0	640.0	662.0	189.0	1580	2.25	73.5	24,700	1.1	27,170	17	Broome	8-8.0'x14.0'	Horseshoe	2-22.0' Diam.	802.8	59,000
	VERMONT																					
16	Williamsville	West	400	7.0	478.0	340.0	335.0	355.0	123.0	1000	1.84	65.2	6,700	1.5	10,050	25	Broome	3-8.0'x15.0'	Horseshoe	1-20.0' Diam.	331.7	21,750
17	Cambridgeport	Saxtons	58	7.0	642.0	560.0	560.0	568.0	74.0	530	2.21	46.4	1,500	1.3	1,950	34	Broome	2-4.0'x8.0'	Horseshoe	1-8.0' Diam.	53.1	2,460
18	Brockway	Williams	101	6.0	552.5	446.0	442.0	454.5	98.0	565	1.95	56.8	4,000	1.3	5,200	52	Broome	3-5.0'x9.5'	Horseshoe	1-12.5' Diam.	129.6	7,360
19	N. Springfield	Black	102*	6.2	528.5	451.0	451.0	460.0	68.5	40	1.30	58.2	9,400	1.4	13,150	129	Broome	5-5.0'x9.0'	Rectangular	5-5.0'x9.0'	225.0	13,100
20	Ludlow	Black	56	8.0	1090.0	999.0	998.0	1006.0	84.0	400	2.16	50.0	650	1.3	850	15	Truck	2-4.0'x8.0'	Horseshoe	1-8.0' Diam.	53.1	2,660
21	North Hartland	Ottauquechee	222	6.0	546.5	396.0	394.0	408.0	138.5	900	2.09	65.9	6,100	1.3	7,930	36	Broome	3-6.0'x10.0'	Horseshoe	1-14.0' Diam.	162.5	10,600
22	South Tunbridge	White (First Branch)	102	6.0	564.0	489.0	487.0	499.0	65.0	530	1.86	47.4	3,700	1.2	4,440	44	Broome	3-5.0'x9.0'	Horseshoe	1-12.0' Diam	119.4	5,660
23	South Randolph	White (Second Branch)	63	7.0	596.5	535.0	535.0	543.0	53.5	320	1.96	41.9	1,630	1.2	1,950	31	Truck	2-4.0'x8.0'	Horseshoe	1-8.0' Diam.	53.1	2,220
24	Ayers Brook	White (Ayers Brook)	30	7.0	697.5	642.0	642.0	650.0	47.5	340	1.82	39.9	770	1.1	850	28	Broome	2-4.0'x8.0'	Horseshoe	1-8.0' Diam.	53.1	2,120
25	Gaysville	White	226	7.0	798.0	642.5	642.5	647.5	150.5	55	1.55	79.0	3,200	1.2	3,840	17	Dow Pivot	4-5.0' Diam.	Circular	4-5.0' Diam.	78.6	6,200
26	Union Village	Ompompanoosuc	126	4.5	554.0	420.0	418.0	431.0	123.0	1197	2.56	65.5	6,800	1.2	7,560	60	Broome	2-7.5'x12.0'	Horseshoe	1-13.0' Diam.	140.1	7,770
27	South Branch	Waits (South Branch)	45	7.0	815.0	733.0	720.0	727.0	88.0	130	1.80	56.1	1,250	1.2	1,500	33	Truck	2-4.0'x6.0'	Horseshoe	1-7.0' Diam.	40.6	2,280
28	Victory	Passumpsic (Moose)	66	8.0	1175.0	1119.5	1119.5	1128.5	46.5	300	1.76	41.2	830	1.1	910	14	Broome	2-5.0'x8.0'	Horseshoe	1-9.0' Diam.	67.2	2,770
29	Lyndonville	Passumpsic	70	7.0	844.0	728.0	727.0	737.0	107.0	750	2.51	52.4	1,430	1.1	1,570	22	Broome	2-5.0'x10.0'	Horseshoe	1-10.0' Diam.	82.9	4,350

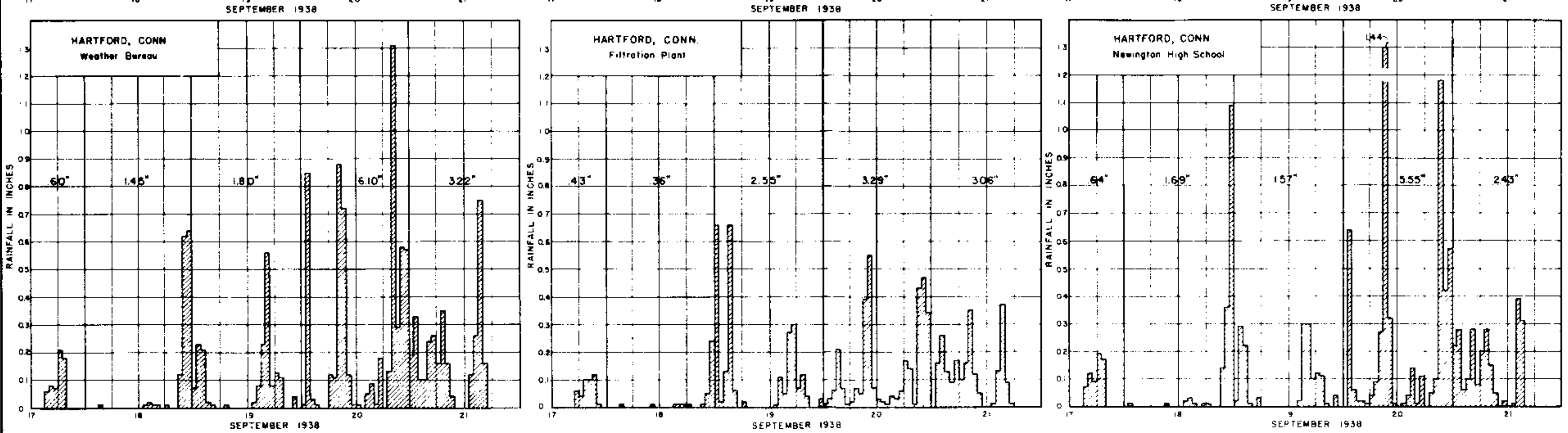
*Net drainage area.

peaks downstream. Stored water will be released as soon as possible after a flood, in order to insure the availability of flood storage capacity in the event of another flood.



APPENDIX PLATE NO. 1





SOURCE OF DATA

U.S. WEATHER BUREAU	CITY OF HARTFORD, CONN.
U.S. ENGINEER DEPARTMENT	CITY OF NEW BRITAIN, CONN.
NEW ENGLAND POWER ASSOCIATION	CITY OF SPRINGFIELD, MASS.
MASSACHUSETTS STATE COLLEGE	

NOTES

Total depths of rainfall in inches for each day are shown above the graphs.
Days are from midnight to midnight.
Rainfall Stations are within the Connecticut River Watershed.

KEY	DATE	REVISION (indicated by △)	REV BY	CK BY	AP BY

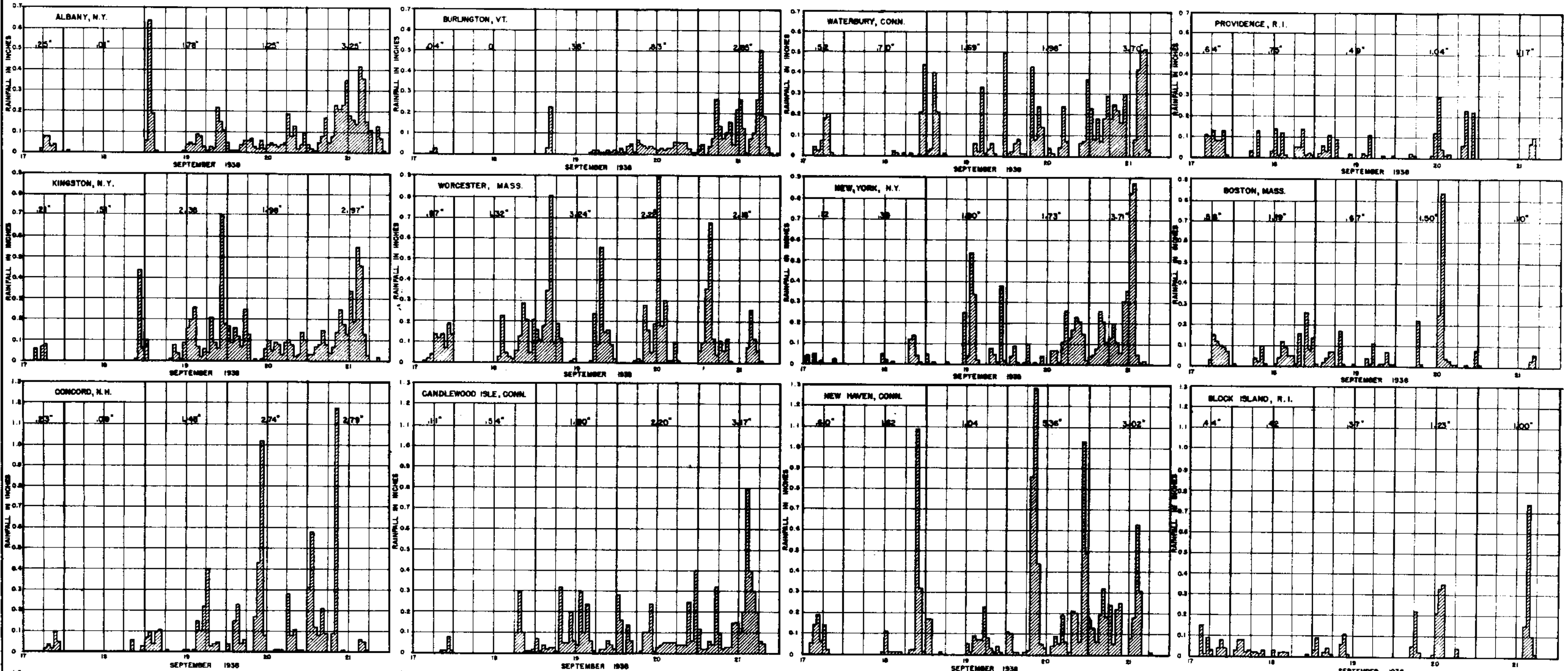
CONNECTICUT RIVER FLOOD CONTROL
NORTHEASTERN UNITED STATES
HOURLY RAINFALL RECORDS
SEPTEMBER 17-21, 1938

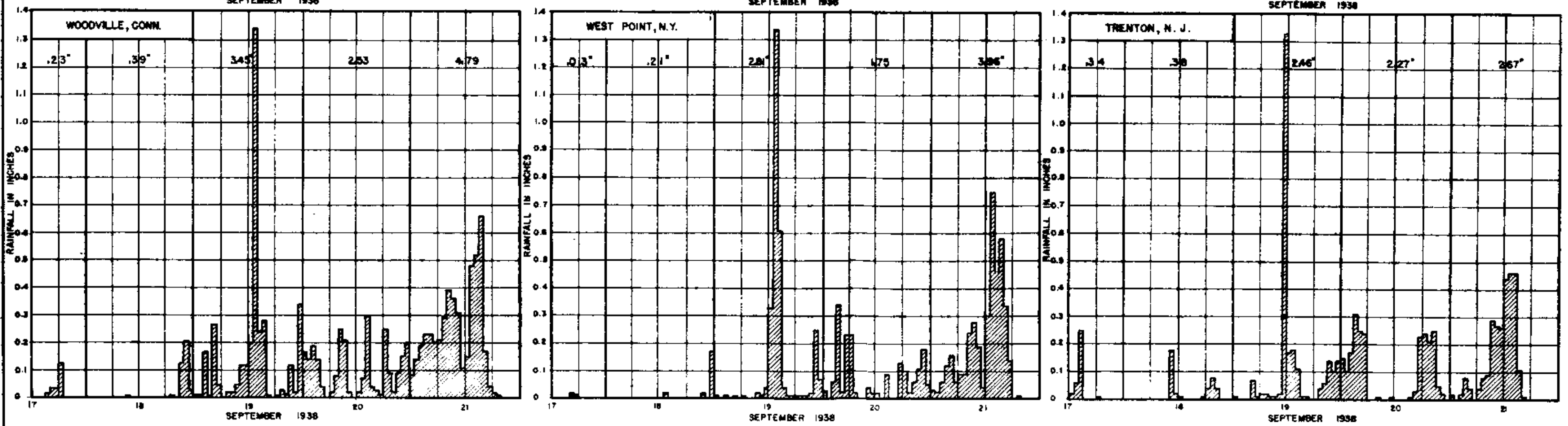
IN 2 SHEETS — SCALE AS SHOWN — SHEET NO. 1

U.S. ENGINEER OFFICE, PROVIDENCE, R.I. — FEB. 1940

SUBMITTED: HEAD, HYDRAULICS SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV. — APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

TO ACCOMPANY REPORT DATED FEB. 28, 1940
FILE NO. CT-3-1125





SOURCE OF DATA

U.S. WEATHER BUREAU
U.S. MILITARY ACADEMY
CONNECTICUT LIGHT & POWER CO.
CITY OF WATERBURY, CONN.
CITY OF WORCESTER, MASS.
CITY OF KINGSTON, N.Y.

NOTES

Total depths of rainfall in inches for each day are shown above the graphs.

Days are from midnight to midnight.

CONNECTICUT RIVER FLOOD CONTROL
NORTHEASTERN UNITED STATES
HOURLY RAINFALL RECORDS
SEPTEMBER 17-21, 1938

IN 2 SHEETS — SCALE AS SHOWN — SHEET NO. 2

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., FEB. 1940

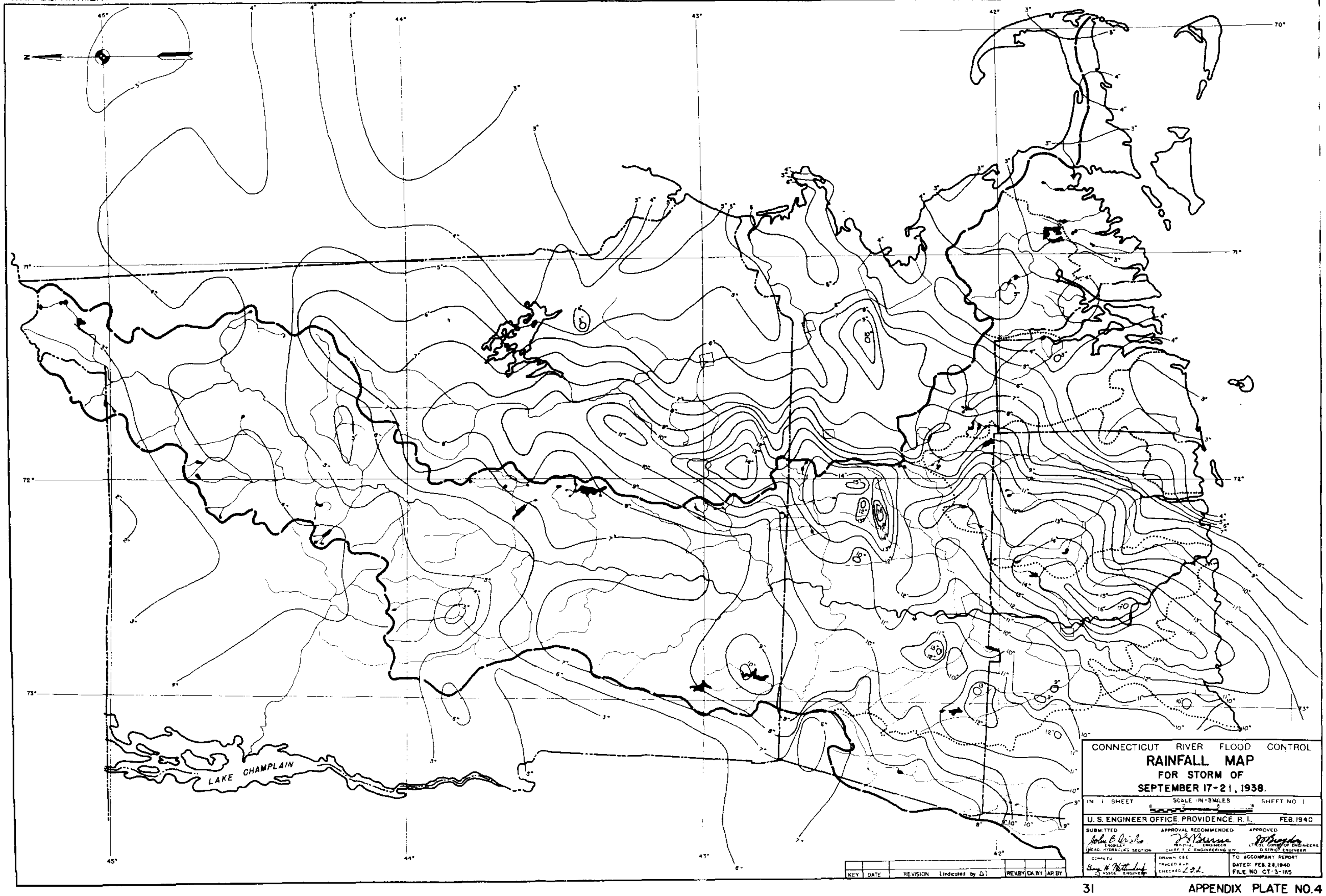
SUBMITTED: ENGINEER, HEAD HYDRAULICS SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, F. C. ENGINEERING DIV. — APPROVED: LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

COMPILED: ASSOC. ENGINEER — DRAWN: D.R.J. TRACED: C.A.C. CHECKED: L.P.L.

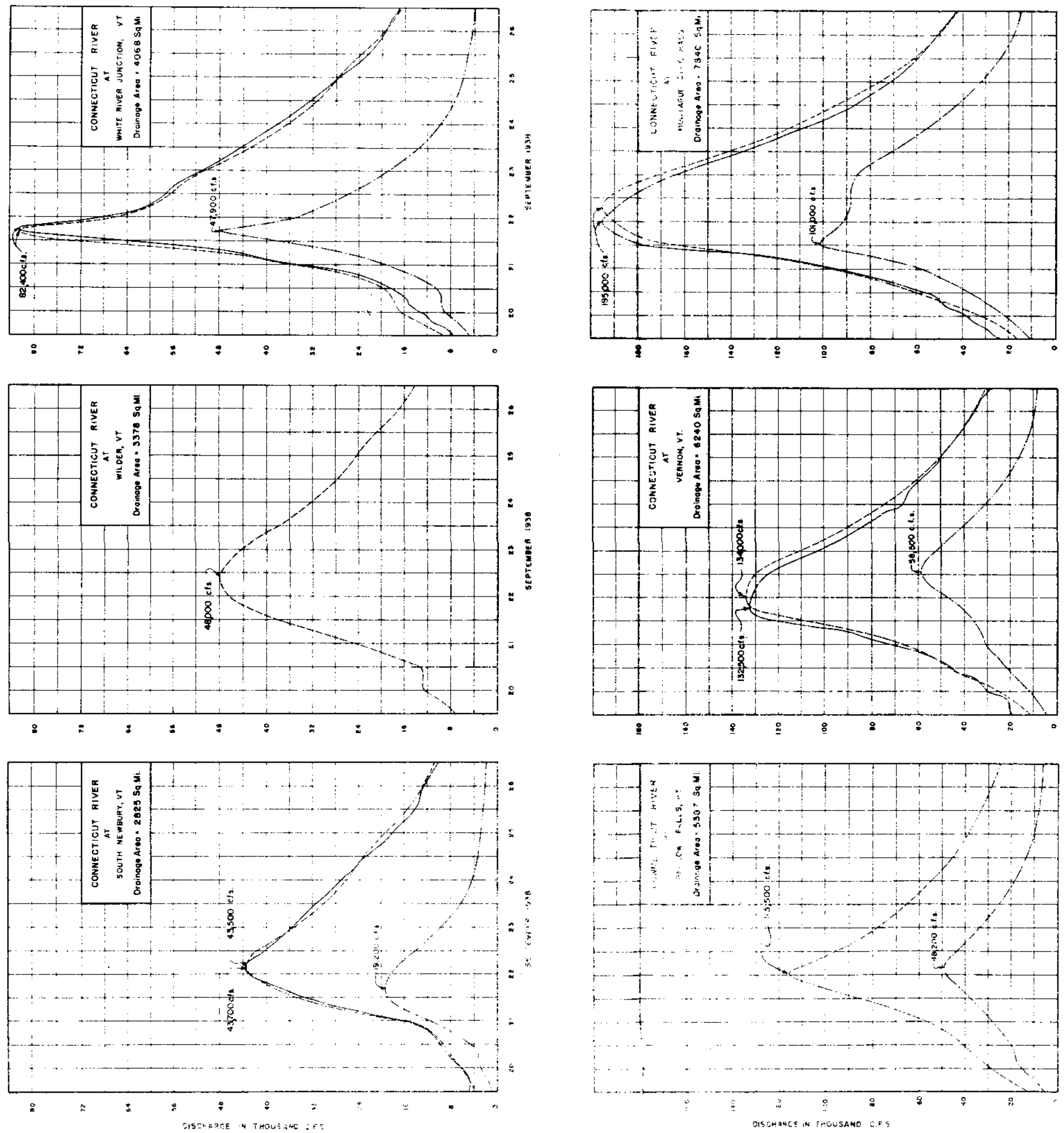
TO ACCOMPANY REPORT DATED FEB. 28, 1940
FILE NO. CT-3-1126

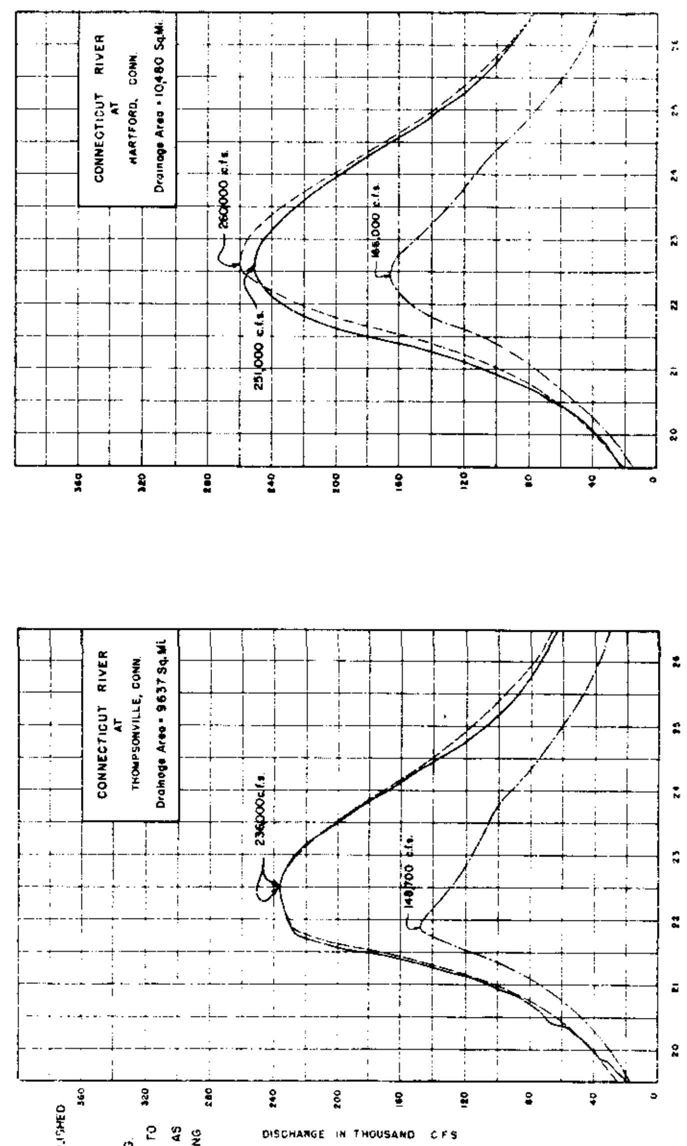
KEY	DATE	REVISION (indicated by △)	REV. BY	CK. BY	AP. BY

WAR DEPARTMENT CORPS OF ENGINEERS, U. S. ARMY



APPENDIX PLATE NO. 4





LEGEND

ACTUAL HYDROGRAPHS AS ESTABLISHED BY STREAM GAGES.

COMPUTED HYDROGRAPHS AS ESTABLISHED BY FLOOD ROUTING.

MODIFIED HYDROGRAPHS DUE TO REVISED COMPREHENSIVE PLAN AS ESTABLISHED BY FLOOD ROUTING.

CONNECTICUT RIVER FLOOD CONTROL

1938 FLOOD HYDROGRAPHS

RECORDED-COMPUTED-MODIFIED

IN 1 SHEET — SCALE AS SHOWN — SHEET NO. 1

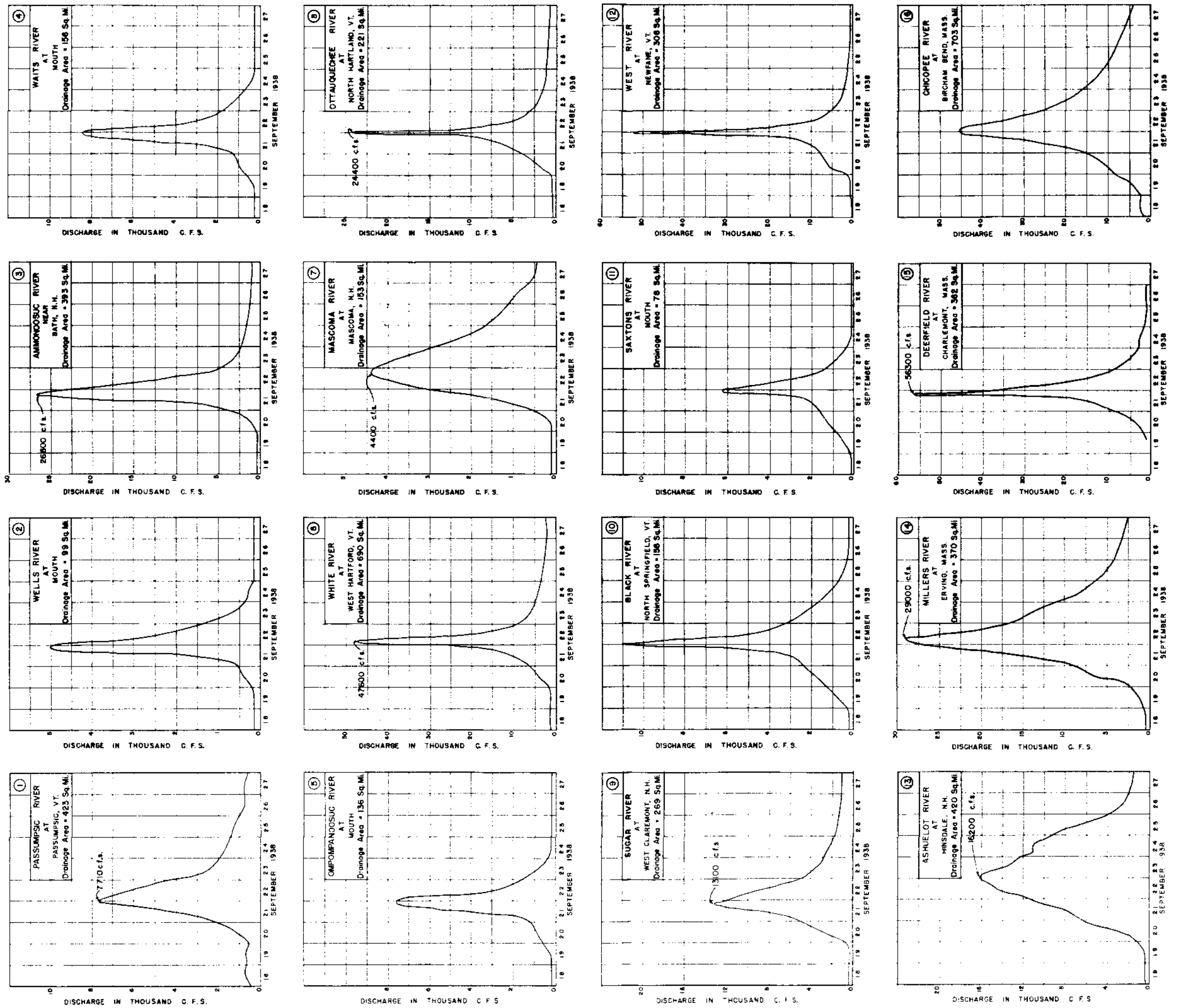
U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — FEB. 1940

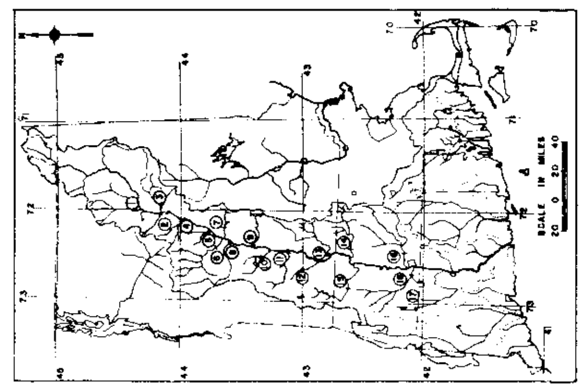
SUBMITTED: ENGINEER, HEAD, HYDRAULICS SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, F. C. ENGINEERING DIV. — APPROVED: LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

COMPILED: ASSOC. ENGINEER — DRAWN BY — TRACED: L.A.O. & F.J.K. — CHECKED

TO ACCOMPANY REPORT DATED FEB. 28, 1940

FILE NO. CT-3-1124





NOTE

Hydrographs were taken from gage records of U. S. Geological Survey except Nos. 2, 4, 5, 10, 11, and 16, which were computed from basic rainfall data applied to unit hydrographs for the areas.

KEY	DATE	REVISION (indicated by Δ)	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

CONNECTICUT RIVER

TRIBUTARY HYDROGRAPHS

SEPTEMBER 1938 FLOOD

IN 1 SHEET — SCALE AS SHOWN — SHEET NO 1

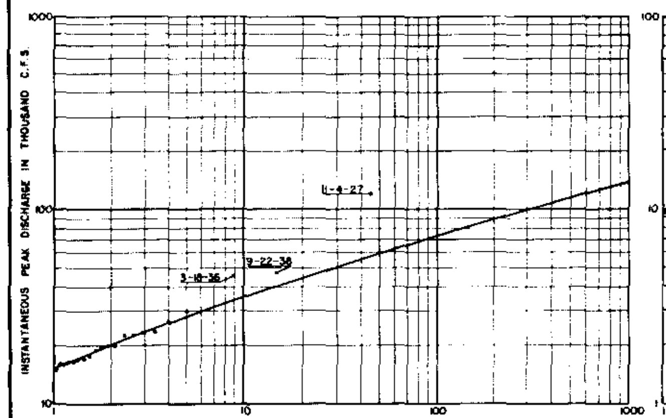
U. S. ENGINEER OFFICE PROVIDENCE, R. I., FEB. 1940

SUBMITTED: ENGINEER, HEAD, HYDRAULICS SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, F. C. ENGINEERING DIV. — APPROVED: LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

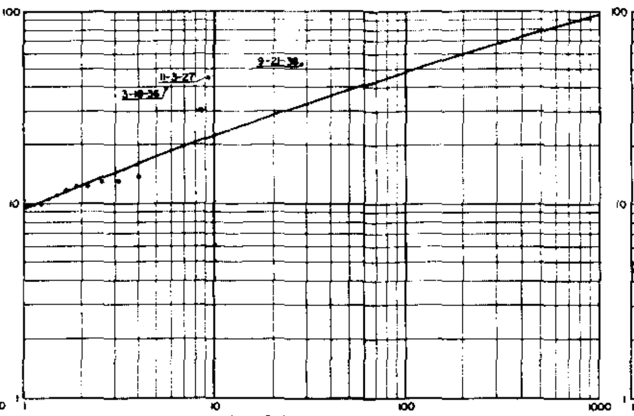
COMPILED: ASSOC. ENGINEER — DRAWN D. R. — TRACED E. S. — CHECKED L. S. L.

TO ACCOMPANY REPORT DATED FEB. 28, 1940

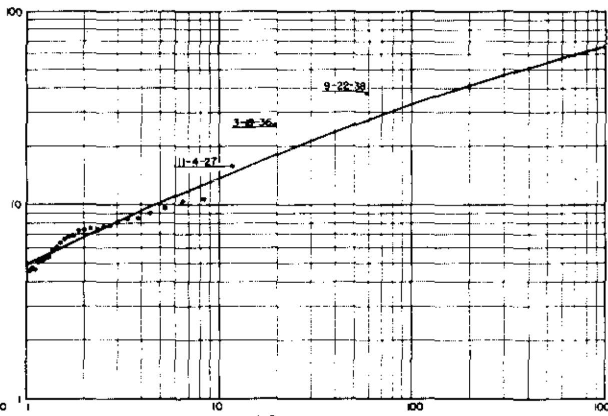
FILE NO. CT-3-1118



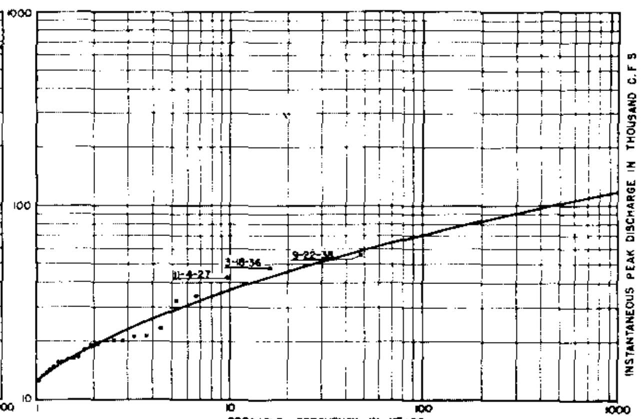
WHITE RIVER AT WEST HARTFORD, VT.
DRAINAGE AREA = 690 SQ. MI.



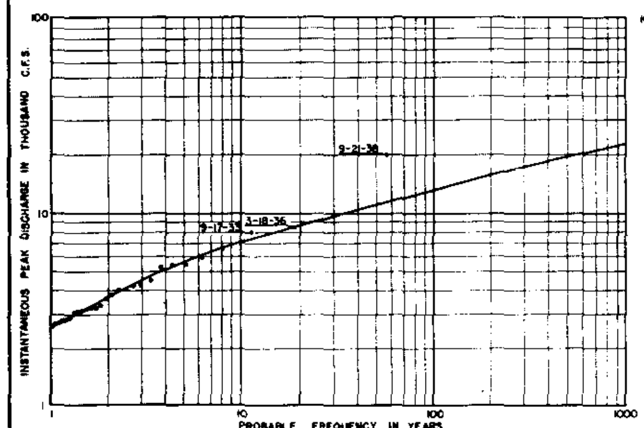
WEST RIVER AT NEWFANE, VT.
DRAINAGE AREA = 308 SQ. MI.



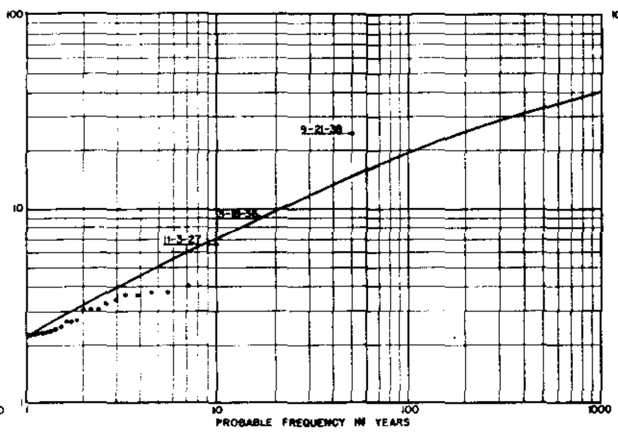
WESTFIELD RIVER AT KNIGHTVILLE, MASS.
DRAINAGE AREA = 162 SQ. MI.



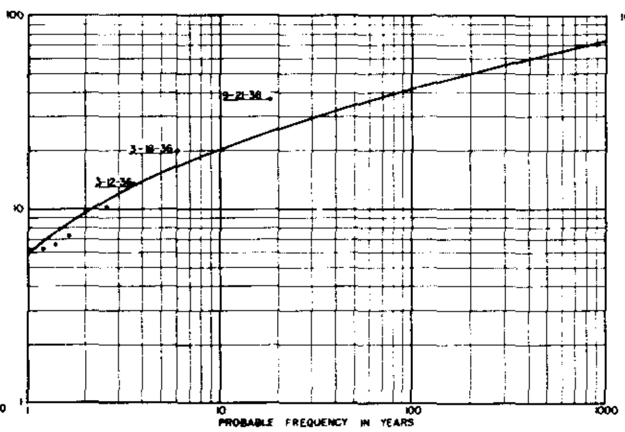
WESTFIELD RIVER NEAR WESTFIELD, MASS.
DRAINAGE AREA = 497 SQ. MI.



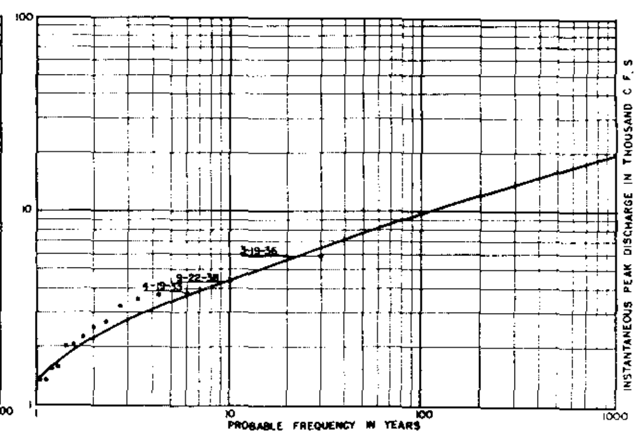
MIDDLE BRANCH OF WESTFIELD RIVER AT GOSS HEIGHTS, MASS.
DRAINAGE AREA = 52.6 SQ. MI.



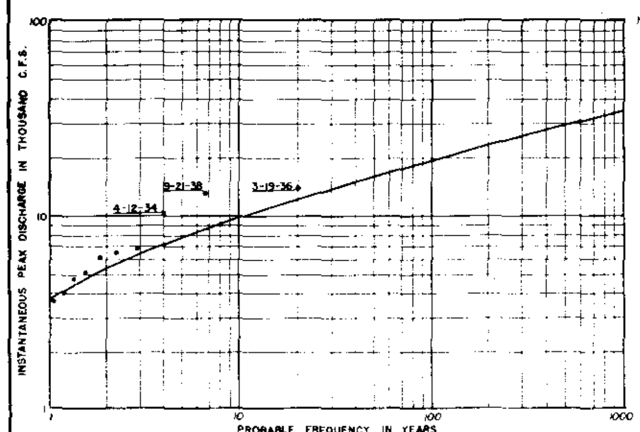
FARMINGTON RIVER NEAR NEW BOSTON, MASS.
DRAINAGE AREA = 92 SQ. MI.



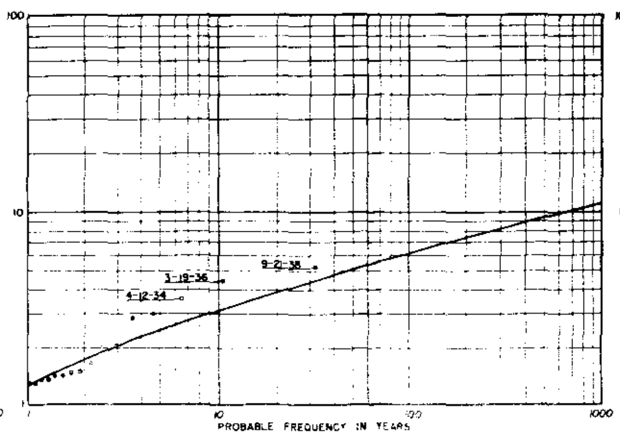
FARMINGTON RIVER AT RIVERTON, CONN.
DRAINAGE AREA = 216 SQ. MI.



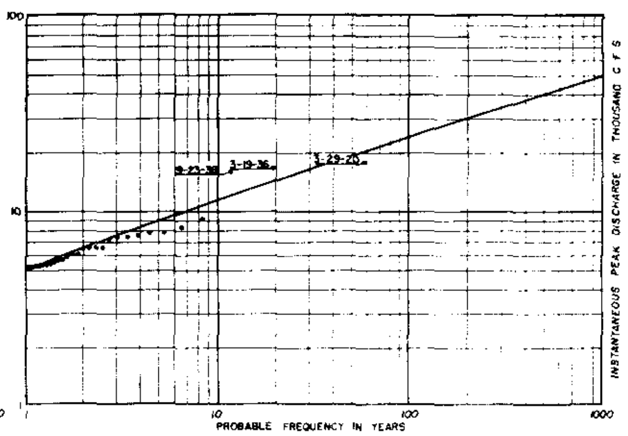
MASCOMA RIVER AT MASCOMA, N. H.
DRAINAGE AREA = 153 SQ. MI.



SUGAR RIVER AT WEST CLAREMONT, N.H.
DRAINAGE AREA = 269 SQ. MI.



ASHUELOT RIVER NEAR GILSUM, N. H.
DRAINAGE AREA = 71.1 SQ. MI.



ASHUELOT RIVER AT HINSDALE, N. H.
DRAINAGE AREA = 420 SQ. MI.

KEY	DATE	REVISION (indicated by △)	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

PROBABLE FREQUENCY OF PEAK DISCHARGE

IN 3 SHEETS — SCALE AS SHOWN — SHEET NO. 1

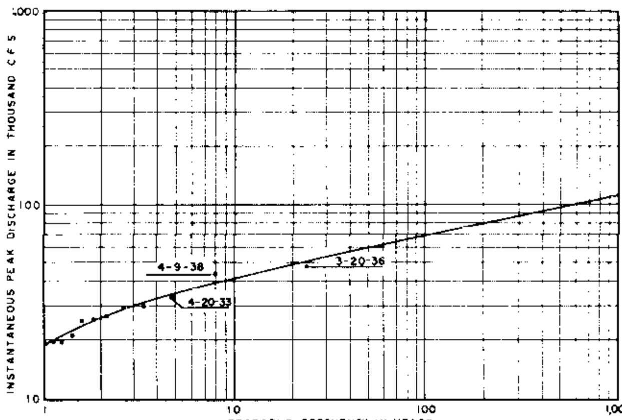
U.S. ENGINEER OFFICE, PROVIDENCE, R.I. FEB. 1940

SUBMITTED — HEAD HYDRAULICS SECTION; APPROVAL RECOMMENDED — CHIEF F.C. ENGINEERING DIV.; APPROVED — DISTRICT ENGINEER

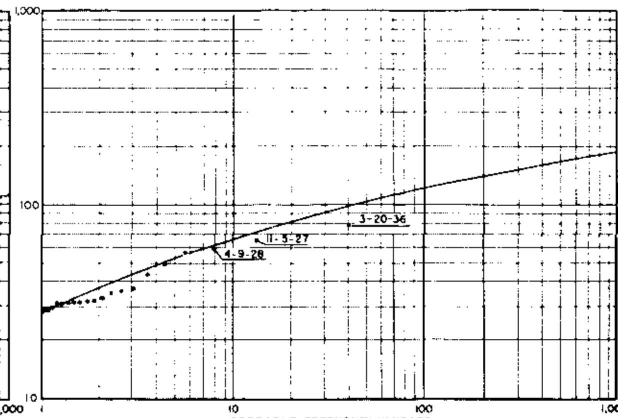
COMPILED; DRAWN; TRACED; CHECKED

TO ACCOMPANY REPORT DATED FEB. 28, 1940

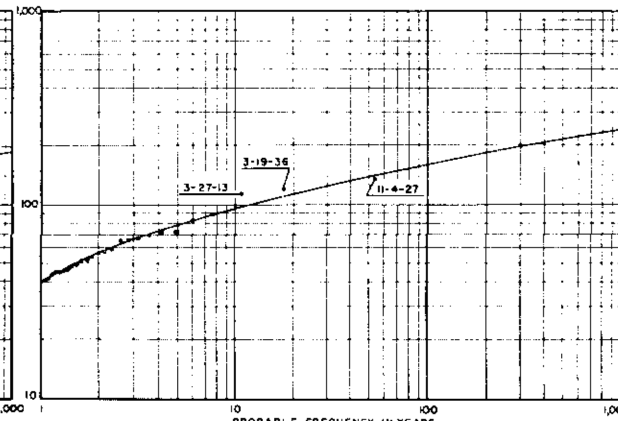
FILE NO. CT-3-1141



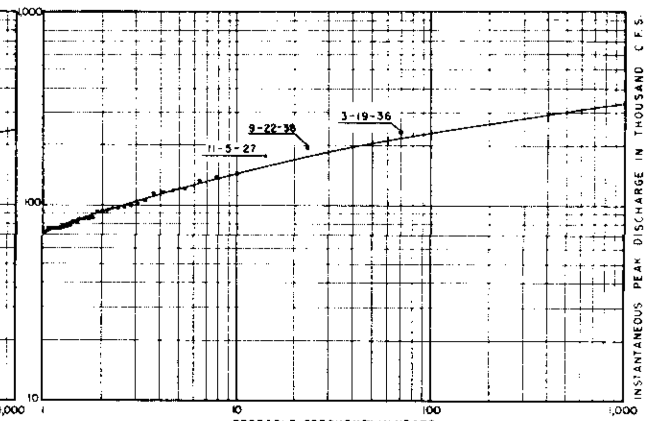
CONNECTICUT RIVER NEAR DALTON, N.H.
DRAINAGE AREA = 1,538 SQ. MI.



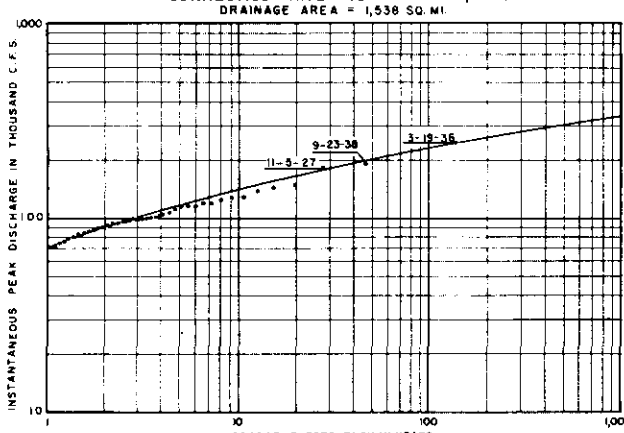
CONNECTICUT RIVER AT SOUTH NEWBURY, VT.
DRAINAGE AREA = 2,825 SQ. MI.



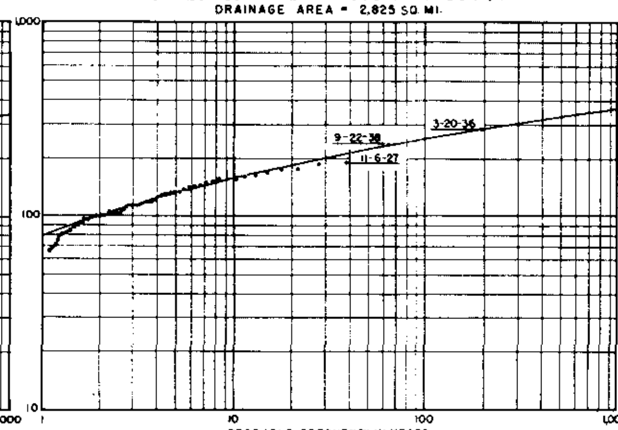
CONNECTICUT RIVER AT WHITE RIVER JUNCTION, VT.
DRAINAGE AREA = 4,068 SQ. MI.



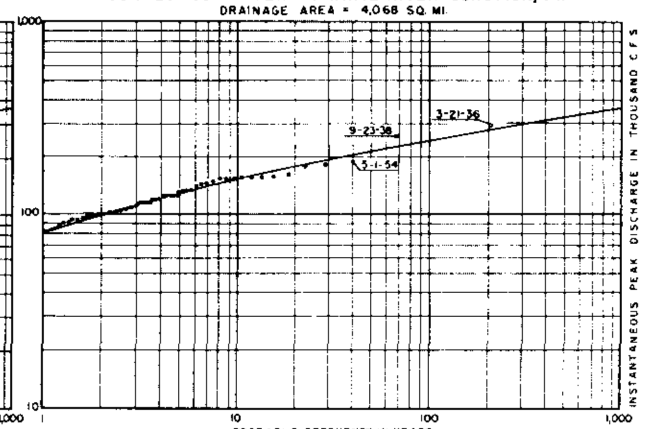
CONNECTICUT RIVER AT MONTAGUE CITY, MASS.
DRAINAGE AREA = 7,840 SQ. MI.



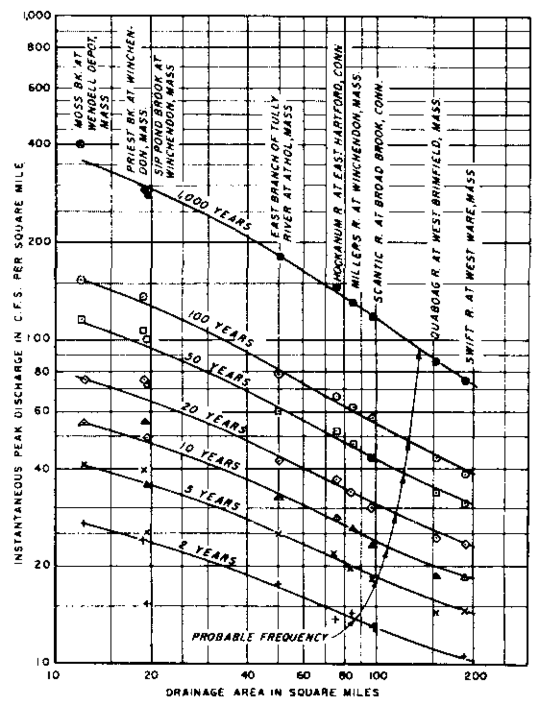
CONNECTICUT RIVER AT HOLYOKE, MASS.
DRAINAGE AREA = 8,284 SQ. MI.



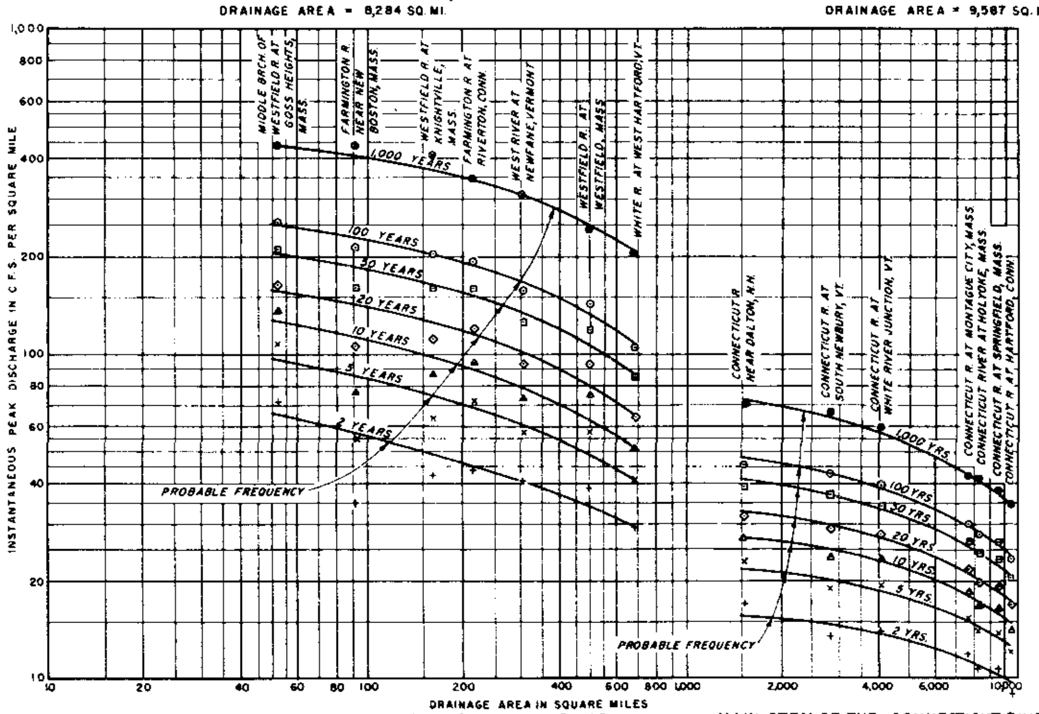
CONNECTICUT RIVER AT SPRINGFIELD, MASS.
DRAINAGE AREA = 9,587 SQ. MI.



CONNECTICUT RIVER AT HARTFORD, CONN.
DRAINAGE AREA = 10,480 SQ. MI.

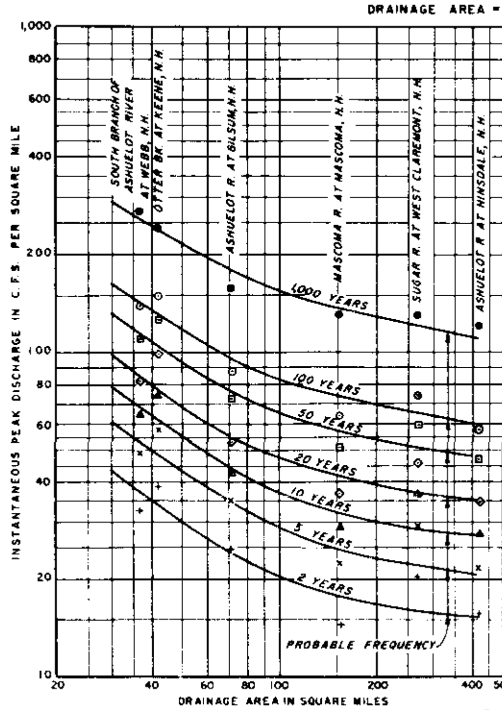


TRIBUTARIES EAST OF THE CONNECTICUT RIVER AND SOUTH OF THE N.H. - MASS. STATE LINE



TRIBUTARIES WEST OF THE CONNECTICUT RIVER AND SOUTH OF THE OMPOMPANOOSUC RIVER, AND ALSO THE AMMONOOSUC RIVER

MAIN STEM OF THE CONNECTICUT RIVER



CONNECTICUT RIVER TRIBUTARIES IN N.H. SOUTH OF THE AMMONOOSUC RIVER

LEGEND

- ● Probable frequency of 1,000 years
- ○ Probable frequency of 100 years
- □ Probable frequency of 50 years
- ◇ Probable frequency of 20 years
- △ Probable frequency of 10 years
- × Probable frequency of 5 years
- + Probable frequency of 2 years

KEY	DATE	REVISION (Indicated by △)	REV BY	CK BY	AP BY

CONNECTICUT RIVER FLOOD CONTROL

PROBABLE FREQUENCY OF PEAK DISCHARGE AND EMPIRICAL FREQUENCY RELATIONS

IN 3 SHEETS — SCALE AS SHOWN — SHEET NO. 3

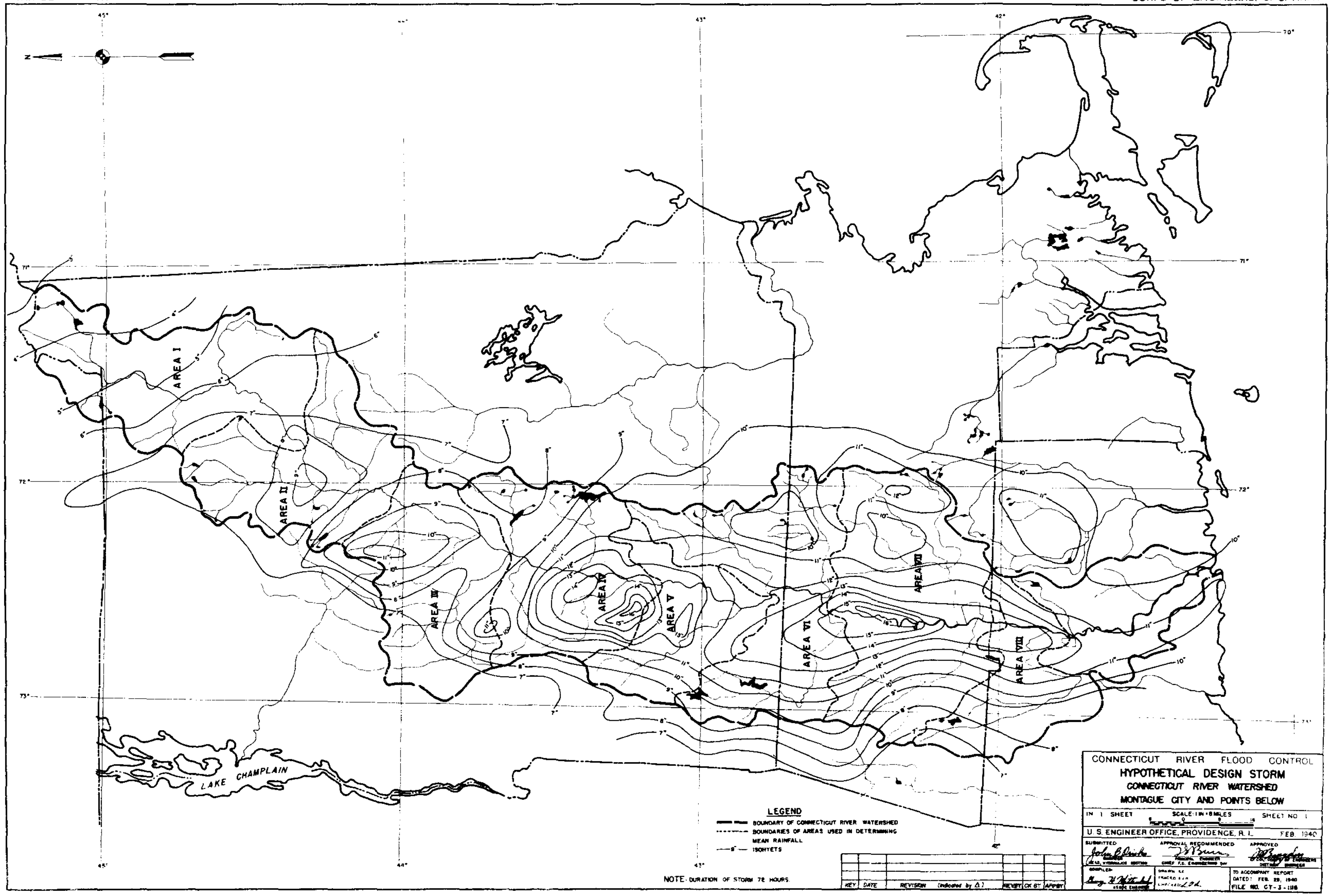
U. S. ENGINEER OFFICE, PROVIDENCE, R. I. — FEB. 1940

SUBMITTED: Head, Hydraulics Section — APPROVAL RECOMMENDED: Principal Engineer, Chief, F. C. Engineering Div. — APPROVED: Lt. Col., Corps of Engineers, District Engineer

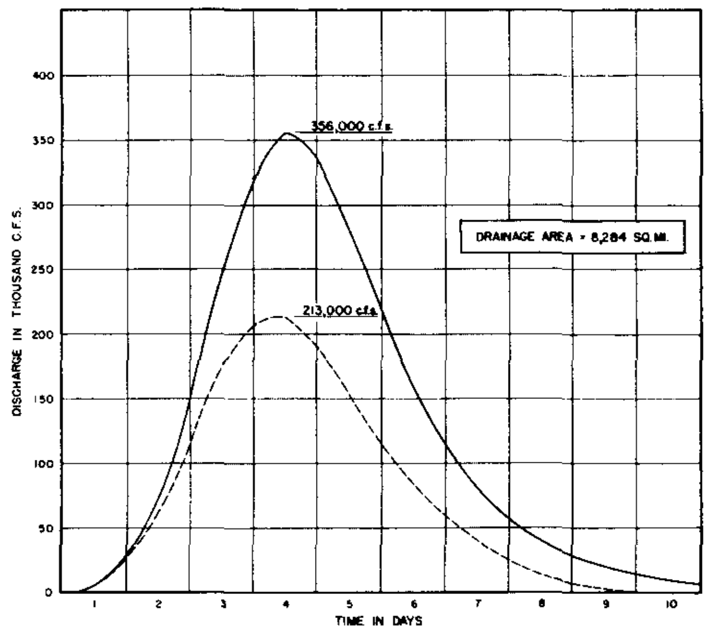
COMPILED: Assoc. Engineer — DRAWN — TRACED — CHECKED

TO ACCOMPANY REPORT DATED FEB. 28, 1940

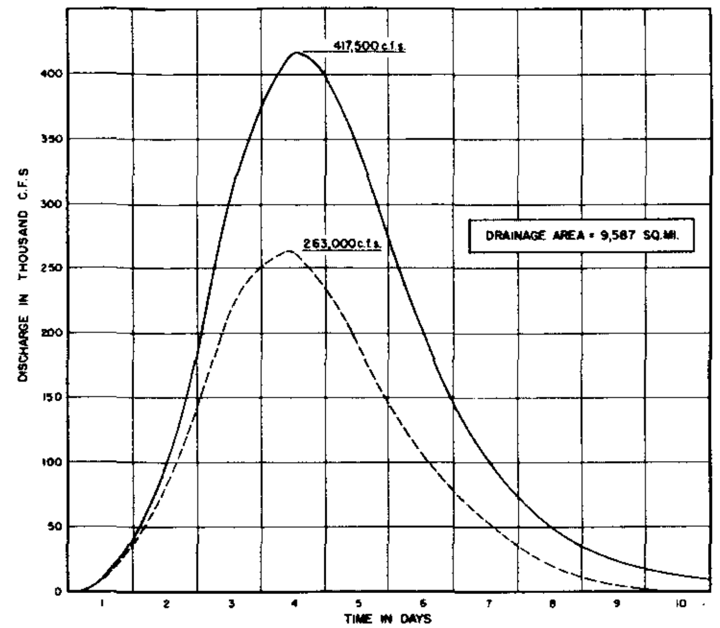
FILE NO. CT-3-1143



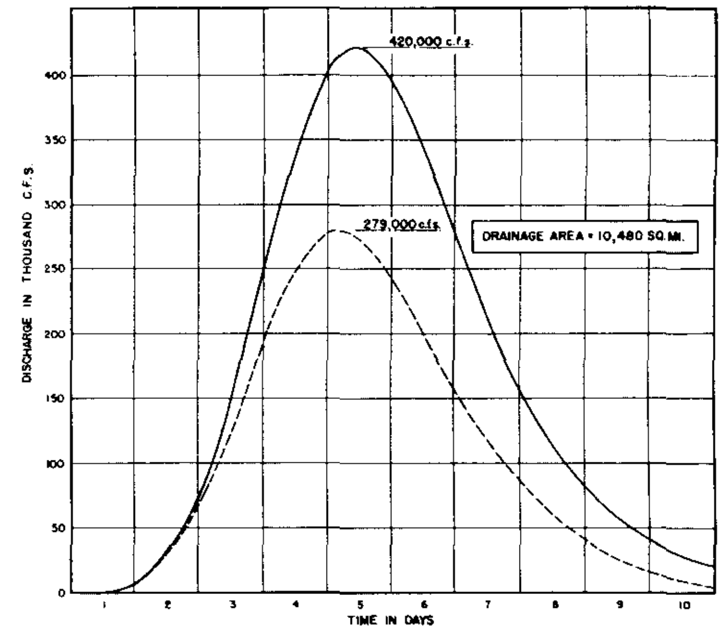
APPENDIX PLATE NO. 10



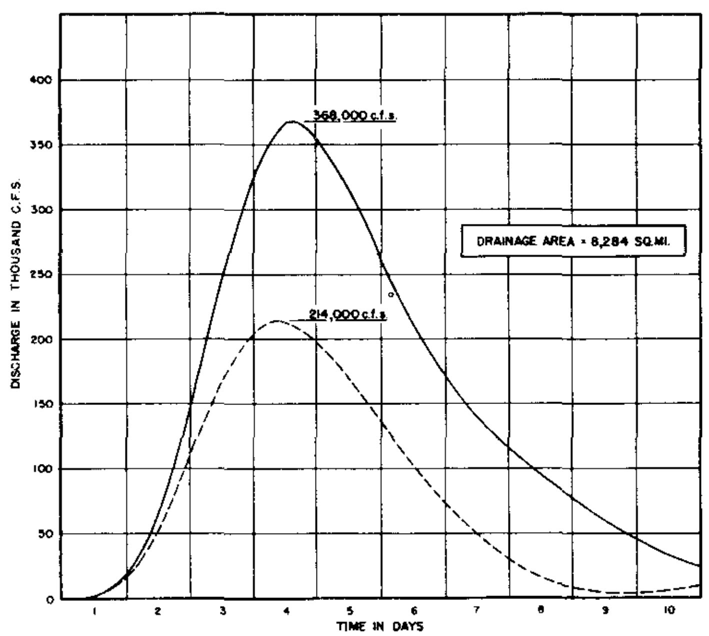
DESIGN FLOOD AT HOLYOKE



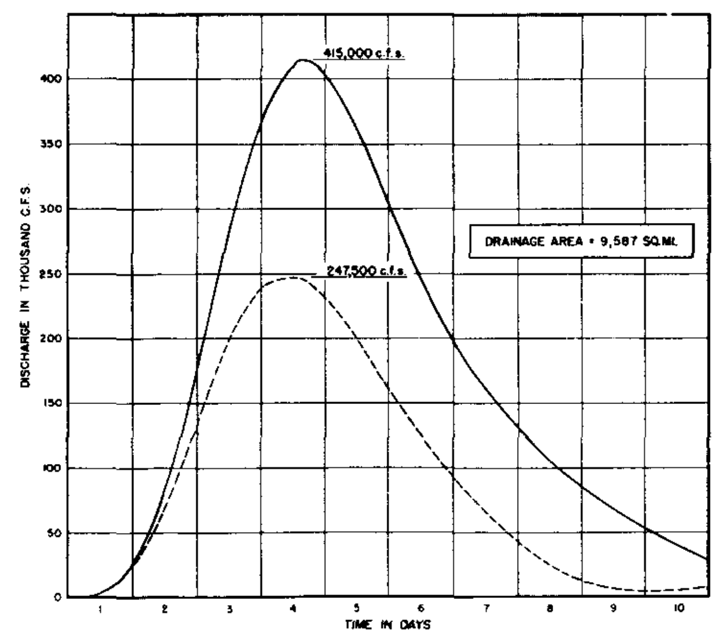
DESIGN FLOOD AT SPRINGFIELD



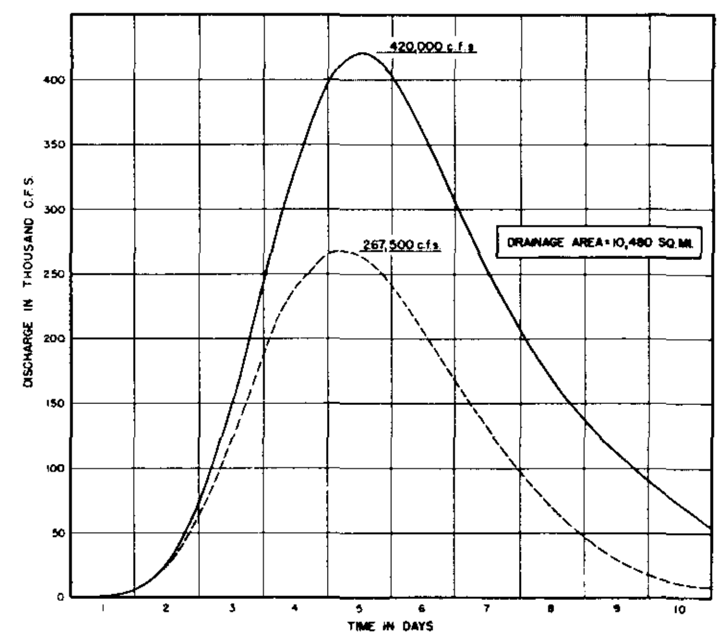
DESIGN FLOOD AT HARTFORD



DEMONSTRATION FLOOD AT HOLYOKE



DEMONSTRATION FLOOD AT SPRINGFIELD



DEMONSTRATION FLOOD AT HARTFORD

LEGEND

——— COMPUTED HYDROGRAPHS.

– – – – COMPUTED HYDROGRAPHS REDUCED BY EFFECT OF REVISED COMPREHENSIVE PLAN OF RESERVOIRS.

KEY	DATE	REVISION (indicated by Δ)	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

DESIGN AND DEMONSTRATION FLOODS AT HOLYOKE, SPRINGFIELD, AND HARTFORD

CONNECTICUT RIVER MASS. AND CONN.

IN 1 SHEET SCALES AS SHOWN SHEET NO. 1

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., FEB 1940

SUBMITTED: Wm B Drake, ENGINEER, HEAD, HYDRAULICS SECTION
APPROVAL RECOMMENDED: J. B. Burns, PRINCIPAL ENGINEER, CHIEF, F. C. ENGINEERING DIV.
APPROVED: J. W. Bragdon, CORPS OF ENGINEERS, DISTRICT ENGINEER

COMPILED: George H. Mittendorf, ASSOC. ENGINEER
DRAWN C.E.S. TRACED J.J.F. CHECKED L.J.L.
TO ACCOMPANY REPORT DATED: FEB. 28, 1940 FILE NO. CT-3-1153

SECTION 2

FLOOD LOSSES

SECTION 2

FLOOD LOSSES

Flood Losses of September 1938

1. GENERAL. - The flood of September 1938 exceeded all previous floods on the tributary streams below White River Junction, Vermont, and was exceeded only by the flood of March 1936 along most of the Connecticut River. Direct flood losses totaled $25,596,000 and eight lives, exclusive of damage from the disastrous hurricane winds and waves which occurred at approximately the same time. This flood, being the third great flood experienced in slightly more than 10 years, sustained and increased the adverse effects upon property value and utilization begun by the floods of 1927 and 1936. Direct losses are summarized in Tables IX to XIII, inclusive. Losses are discussed by basins in the following paragraphs.

2. CONNECTICUT RIVER. - The Connecticut River did not cause important damage in Vermont and New Hampshire because the crest stage ranged from about 12 feet below the 1936 peak stage in the upper valley to about 5 feet below towards the southern limits of these states. Damage to railroads, farm lands, and other property close to the banks of the river was considerably increased by the wave wash caused by hurricane winds. Due to record flows on tributary streams, the flood on the Connecticut River increased as it progressed downstream until it crested approximately three feet below the record 1936 peak stages at the main damage centers of Massachusetts and Connecticut. Greenfield, located on the Green River in upper Massachusetts, was flooded by the backwater of the Connecticut River. About 46 dwellings were evacuated, and three industries were damaged. Twenty houses and 1200 acres of farm land in Deerfield were similarly affected. At Hatfield, Hadley, and South Hadley, local levees failed to give protection, and the village centers, including several hundred homes and approximately 2500 acres of tobacco and other

TABLE IX

CONNECTICUT RIVER WATERSHED

DIRECT FLOOD LOSSES - 1938 FLOOD, BY STATES AND TRIBUTARIES.

BY STATES

STATE	URBAN*	AGRICULTURAL	INDUSTRIAL**	HIGHWAY	RAILROAD	TOTAL	PERCENT
VERMONT	$ 407,000	$ 231,000	$ 267,000	$2,839,000	$ 65,000	$ 3,809,000	14.9
NEW HAMPSHIRE	269,000	106,000	240,000	419,000	91,000	1,125,000	4.4
MASSACHUSETTS	2,777,000	905,000	4,735,000	5,508,000	1,628,000	15,553,000	60.7
CONNECTICUT	1,686,000	681,000	1,772,000	875,000	95,000	5,109,000	20.0
TOTALS	5,139,000	1,923,000	7,014,000	9,641,000	1,879,000	25,596,000	100.0
PERCENT OF TOTAL	20.0	7.6	27.4	37.7	7.3	100.0	

BY TRIBUTARIES

RIVER BASIN	STATE	URBAN*	AGRICULTURAL	INDUSTRIAL**	HIGHWAY	RAILROAD	TOTAL
CONNECTICUT (1)	CONN.-MASS. N.H. & VT.	$2,396,400	$ 830,900	$2,344,500	$ 664,400	$ 159,800	$ 6,396,000
ISRAEL #	N.H.	-	-	-	15,000	1,000	16,000
PASSUMPSIC	VT.	2,300	4,700	700	1,300	-	9,000
STEVENS	VT.	-	-	-	2,000	-	2,000
WELLS	VT.	-	-	-	6,000	-	6,000
AMMONOOSUC	N.H.	23,800	11,300	7,700	19,500	1,700	64,000
WAITS	VT.	-	-	-	6,000	-	6,000
OMPOMPANOOSUC	VT.	-	-	-	11,000	-	11,000
WHITE	VT.	13,500	30,900	29,600	230,300	3,700	308,000
MASCOMA	N.H.	26,100	2,300	13,200	12,800	2,600	57,000
OTTAUQUECHEE	VT.	4,600	15,200	83,200	177,000	-	280,000
SUGAR (4)	N.H.	30,900	2,100	2,400	4,600	-	40,000
BLACK	VT.	122,400	31,800	74,500	169,300	-	398,000
WILLIAMS # (2)	VT.	3,000	9,000	-	187,000	10,000	209,000
SAXTONS #	VT.	4,500	3,500	2,000	184,000	-	194,000
COLD	N. H.	-	5,300	-	18,700	-	24,000
WEST	VT.	64,200	46,300	24,400	688,100	-	823,000
ASHUELOT	N.H.	167,700	55,000	199,400	158,700	32,200	613,000
MILLERS (5)	MASS.-N.H.	624,400	76,100	1,298,900	733,600	995,000	3,728,000
DEERFIELD (6)	VT.-MASS.	365,000	184,500	323,100	3,037,500	197,900	4,108,000
CHICOPEE (7)	MASS.	719,300	135,000	1,775,400	1,840,800	310,500	4,781,000
WESTFIELD	MASS.	177,200	31,900	463,600	593,200	75,100	1,341,000
FARMINGTON (3)	CONN.-MASS.	260,400	383,500	231,700	344,300	34,100	1,254,000
MISC. - OTHER STREAMS #	VARIOUS	133,300	63,700	139,700	535,900	55,400	928,000
TOTALS		5,139,000	1,923,000	7,014,000	9,641,000	1,879,000	25,596,000

** INDUSTRIAL AND UTILITY LOSSES.
# NO DETAILED INVESTIGATION MADE.
(1) EXCLUSIVE OF TRIBUTARIES LISTED IN TABLE. NO COMPLETE INVESTIGATION MADE IN MASSACHUSETTS AND CONNECTICUT.
(2) THERE WAS ONE LIFE LOST IN THE WILLIAMS RIVER BASIN.
(3) THERE WERE TWO LIVES LOST IN THE FARMINGTON RIVER BASIN.
(4) THERE WAS ONE LIFE LOST IN THE SUGAR RIVER BASIN.
(5) THERE WAS ONE LIFE LOST IN THE MILLERS RIVER BASIN.
(6) THERE WAS ONE LIFE LOST IN THE DEERFIELD RIVER BASIN.
(7) THERE WERE TWO LIVES LOST IN THE CHICOPEE RIVER BASIN.
* RESIDENTIAL, PUBLIC AND COMMERCIAL LOSSES.

TABLE X

DIRECT FLOOD LOSSES - CONNECTICUT RIVER WATERSHED - 1938 FLOOD

STATE OF VERMONT

SUMMARY OF DIRECT LOSSES AND ASSESSED VALUATIONS
OF TOWNS SUSTAINING LOSSES.

TOWN	DAM-AGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938 URBAN	AGRI-CULTURE	INDUS-TRIAL	HIGH-WAY	RAIL-ROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ANDOVER	*	177,625	$ -	$ 2,900	$ -	$ 44,000	-	$ 46,900
ATHENS	12-A	104,910	-	-	-	7,500	-	7,500
BARNET	C-1		-	-	-	-	3,000	3,000
BARNET	2-A		-	-	-	1,800	-	1,800
BARNET	*		-	200	-	-	-	** 200
BARNET, TOTALS		2,662,797	-	200	-	1,800	3,000	5,000
BARNARD	*	434,575	-	-	-	22,000	-	22,000
BETHEL	7-A		1,100	7,900	-	30,000	700	39,700
BETHEL	7-B		500	-	-	-	-	500
BETHEL	7-E		-	-	28,000	-	-	28,000
BETHEL, TOTALS		1,020,656	1,600	7,900	28,000	30,000	700	68,200
BLOOMFIELD	*	315,749	1,000	1,000	-	2,000	2,000	** 6,000
BRADFORD	C-2		-	700	-	-	2,000	2,700
BRADFORD	5-A		-	-	-	2,000	-	2,000
BRADFORD, TOTALS		1,102,979	-	700	-	2,000	2,000	4,700
BRAINTREE	7-V	412,253	-	300	-	-	1,000	1,300
BRATTLEBORO	13-A		200	700	-	5,000	-	5,900
BRATTLEBORO	C-5		2,000	-	1,000	2,000	-	5,000
BRATTLEBORO	*		5,000	-	10,000	-	-	15,000
BRATTLEBORO, TOTALS		8,213,900	7,200	700	11,000	7,000	-	25,900
BRIDGEWATER	9-W		1,500	1,700	21,500	2,000	-	26,700
BRIDGEWATER	*		3,000	3,000	200	84,900	-	91,100
BRIDGEWATER, TOTALS		601,627	4,500	4,700	21,700	86,900	-	117,800
BROOKLINE	13-Z	72,575	-	2,200	-	-	-	** 2,200
BROOKFIELD	*	484,315	-	-	-	3,500	-	** 3,500
BURKE	*	682,363	100	800	100	-	-	1,000
CAVENDISH	11-A		8,900	8,500	6,200	10,000	-	33,600
CAVENDISH	*		-	12,000	2,700	28,000	-	42,700
CAVENDISH, TOTALS		1,060,425	8,900	20,500	8,900	38,000	-	76,300
CHELSEA	*	579,378	-	-	-	3,700	-	3,700
CHESTER	*	1,394,014	1,000	5,000	-	100,000	5,000	111,000
CHITTENDEN	*	681,406	-	-	-	7,000	-	7,000
CONCORD	1-D		100	-	-	-	-	100
CONCORD	*		1,000	1,000	-	-	-	2,000
CONCORD, TOTALS		880,295	1,100	1,000	-	-	-	2,100
CORINTH	5-A	476,715	-	-	-	2,000	-	2,000
DOVER	16-Z		6,000	-	-	-	-	6,000
DOVER	*		-	-	-	37,900	-	37,900
DOVER, TOTALS		287,496	6,000	-	-	37,900	-	43,900
DUMMERSTON	13-A		100	2,400	1,200	10,000	-	13,700
DUMMERSTON	*		-	-	-	15,000	-	15,000
DUMMERSTON, TOTALS		561,850	100	2,400	1,200	25,000	-	28,700

TABLE X (CONTINUED)
STATE OF VERMONT

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938: URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
FAIRLEE	*	$ 936,629	$ -	$ -	$ -	$ -	$1,000	$ 1,000
GRAFTON	12-A		4,500	3,500	2,000	106,000	-	116,000
GRAFTON	*		-	-	-	29,500	-	29,500
GRAFTON, TOTALS		343,034	4,500	3,500	2,000	135,500	-	145,500
GRANVILLE	7-Y		2,400	-	-	4,000	-	6,400
GRANVILLE	*		-	-	-	16,300	-	16,300
GRANVILLE, TOTALS		208,100	2,400	-	-	20,300	-	22,700
GROTON	3-A	547,400	-	-	-	2,000	-	2,000
GUILFORD	16-W		-	-	700	5,000	-	5,700
GUILFORD	*		2,100	-	400	41,000	-	** 43,500
GUILFORD, TOTALS		464,547	2,100	-	1,100	46,000	-	49,200
HALIFAX	16-X		-	27,700	2,100	33,100	-	62,900
HALIFAX	*		-	-	-	233,900	-	233,900
HALIFAX, TOTALS		225,427	-	27,700	2,100	267,000	-	296,800
HANCOCK	7-Y		5,800	15,800	-	4,000	-	25,600
HANCOCK	*		-	-	-	25,800	-	25,800
HANCOCK, TOTALS		349,121	5,800	15,800	-	29,800	-	51,400
HARTFORD	C-2		1,600	-	-	-	-	1,600
HARTFORD	7-D		200	-	1,600	-	-	1,800
HARTFORD	9-W		-	-	31,000	-	-	31,000
HARTFORD	*		-	-	-	14,000	-	14,000
HARTFORD, TOTALS		4,250,773	1,800	-	32,600	14,000	-	48,400
HARTLAND	*	886,546	-	-	-	2,400	-	** 2,400
JAMAICA	13-Z		100	6,000	-	2,000	-	8,100
JAMAICA	13-Y		-	-	-	5,000	-	5,000
JAMAICA	*		1,500	16,500	8,000	158,000	-	184,000
JAMAICA, TOTALS		344,865	1,600	22,500	8,000	165,000	-	197,100
LONDONDERRY	*	468,785	21,500	-	-	30,000	-	51,500
LUDLOW	11-A		76,900	-	11,900	-	-	88,800
LUDLOW	*		22,100	1,100	50,000	42,200	-	115,400
LUDLOW, TOTALS		1,539,785	99,000	1,100	61,900	42,200	-	204,200
LYNDON	1-A		100	1,500	100	200	-	1,900
LYNDON	1-B		200	600	-	200	-	1,000
LYNDON, TOTALS		2,016,770	300	2,100	100	400	-	2,900
MT. HOLLY	*	472,351	-	-	-	28,000	-	28,000
MARLBORO	*	198,210	1,200	1,000	-	92,600	-	94,800
NEWBURY	C-1		1,600	3,600	-	-	12,000	17,200
NEWBURY	3-A		-	-	-	2,000	-	2,000
NEWBURY, TOTALS		1,454,300	1,600	3,600	-	2,000	12,000	19,200

TABLE X (CONTINUED)
STATE OF VERMONT

TOWN (1)	DAMAGE ZONE (2)	ASSESSED VALUES 1935 (3)	DIRECT FLOOD LOSSES- SEPTEMBER 1938: URBAN (4)	AGRICULTURE (5)	INDUSTRIAL (6)	HIGHWAY (7)	RAILROAD (8)	TOTAL (9)
NEWFANE	13-A	$	$ -	$ 200	$ -	$ -	$ -	$ 200
NEWFANE	13-Z		-	2,600	-	3,000	-	5,600
NEWFANE	*		13,600	1,700	10,000	65,000	-	90,300
NEWFANE, TOTALS		451,525	13,600	4,500	10,000	68,000	-	96,100
NORWICH	C-2	1,060,830	-	100	-	-	14,000	14,100
PITTSFIELD	*	172,210	-	-	-	6,000	-	6,000
PLYMOUTH	*	322,826	-	-	-	50,100	-	50,100
POMFRET	*	526,775	-	-	-	11,000	-	11,000
PUTNEY	C-5		200	100	-	1,000	1,700	3,000
PUTNEY	*		-	15,600	6,000	5,100	-	26,700
PUTNEY, TOTALS		607,656	200	15,700	6,000	6,100	1,700	29,700
RANDOLPH	7-E	2,401,640	2,000	-	-	-	-	2,000
READING	*	393,000	-	4,500	-	31,100	-	35,600
READSBORO	16-Y		-	-	7,300	3,600	-	10,900
READSBORO	*		3,000	3,000	200	91,200	-	97,400
READSBORO, TOTALS		928,624	3,000	3,000	7,500	94,800	-	108,300
ROCHESTER	7-Y		-	2,100	-	10,000	-	12,100
ROCHESTER	*		-	-	-	24,000	-	24,000
ROCHESTER, TOTALS		767,070	-	2,100	-	34,000	-	36,100
ROCKINGHAM	C-4		-	-	-	20,000	-	20,000
ROCKINGHAM	C-5		400	-	-	-	-	400
ROCKINGHAM	12-A		-	-	-	5,000	-	5,000
ROCKINGHAM	*		-	-	-	2,300	5,000	** 7,300
ROCKINGHAM, TOTALS		10,725,688	400	-	-	27,300	5,000	32,700
ROYALTON	7-B		100	-	-	-	2,000	2,100
ROYALTON	7-C		-	-	-	2,000	-	2,000
ROYALTON	7-D		-	-	-	1,000	-	1,000
ROYALTON, TOTALS		1,048,281	100	-	-	3,000	2,000	5,100
RYGATE	C-1		-	-	-	-	1,000	1,000
RYGATE	3-A		-	-	-	2,000	-	** 2,000
RYGATE, TOTALS		1,034,448	-	-	-	2,000	1,000	3,000
SEARSBURG	*	594,914	-	-	-	14,500	-	14,500
SHARON	7-D		-	-	-	400	-	400
SHARON	*		-	-	-	13,000	-	13,000
SHARON, TOTALS		366,513	-	-	-	13,400	-	13,400
SHERBURNE	*	213,389	-	-	-	8,100	-	8,100
SPRINGFIELD	11-C		16,100	2,600	3,400	-	-	22,100
SPRINGFIELD	*		-	-	-	9,500	-	** 9,500
SPRINGFIELD, TOTALS		9,438,052	16,100	2,600	3,400	9,500	-	31,600

TABLE X (CONTINUED)
STATE OF VERMONT

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938: URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ST. JOHNSBURY	1-B	$	$ 1,800	$ 200	$ 200	$ 200	$ -	$ 2,400
ST. JOHNSBURY	1-C		-	-	1,200	-	-	1,200
ST. JOHNSBURY	1-D		-	100	-	-	-	100
ST. JOHNSBURY, TOTALS		7,522,676	1,800	300	1,400	200	-	3,700
STOCKBRIDGE	7-A		300	3,900	-	2,000	-	6,200
STOCKBRIDGE	7-Y		-	900	-	15,000	-	15,900
STOCKBRIDGE	*		-	-	-	40,000	-	40,000
STOCKBRIDGE, TOTALS		339,133	300	4,800	-	57,000	-	62,100
STRAFFORD	*	383,453	-	-	-	6,000	-	6,000
STRATTON	*	147,906	-	-	-	4,300	-	** 4,300
THETFORD	C-2		-	200	-	-	7,000	7,200
THETFORD	*		-	-	-	3,100	-	3,100
THETFORD, TOTALS		708,672	-	200	-	3,100	7,000	10,300
TOPSHAM	5-A	428,071	-	-	-	2,000	-	2,000
TOWNSHEND	12-A		-	-	-	24,000	-	24,000
TOWNSHEND	13-Z		700	8,900	1,000	10,000	-	20,600
TOWNSHEND	*		2,000	-	500	88,500	-	91,000
TOWNSHEND, TOTALS		443,093	2,700	8,900	1,500	122,500	-	135,600
TUNBRIDGE	7-X		1,100	-	-	1,300	-	2,400
TUNBRIDGE	*		-	-	-	7,000	-	7,000
TUNBRIDGE, TOTALS		545,378	1,100	-	-	8,300	-	9,400
VERNON	C-5		-	-	1,300	-	-	1,300
VERNON	*		1,000	-	-	-	-	1,000
VERNON, TOTALS		955,227	1,000	-	1,300	-	-	2,300
VERSHIRE	*	177,311	-	-	-	1,400	-	1,400
WARDSBORO	*	191,600	3,500	3,100	3,000	184,200	-	193,800
WEATHERSFIELD	11-B		-	4,200	-	-	-	4,200
WEATHERSFIELD	*		-	-	-	39,200	-	39,200
WEATHERSFIELD, TOTALS		825,941	-	4,200	-	39,200	-	43,400
WESTMINSTER	C-5		-	1,000	-	2,000	1,000	4,000
WESTMINSTER	12-A		-	-	-	4,500	-	4,500
WESTMINSTER, TOTALS		855,291	-	1,000	-	6,500	1,000	8,500
WESTON	*	264,400	20,000	-	-	10,000	-	30,000
WHITINGHAM	16-X		35,700	8,000	11,500	39,400	-	94,600
WHITINGHAM	*		-	-	-	90,800	-	90,800
WHITINGHAM, TOTALS		3,985,841	35,700	8,000	11,500	130,200	-	185,400

TABLE X (CONTINUED)
STATE OF VERMONT

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES – SEPTEMBER 1938 URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
WILMINGTON	16-Z	$	$60,000	$ -	$ -	$ 130,000	$ -	$ 190,000
WILMINGTON	*		69,500	18,400	10,000	278,500	-	376,400
WILMINGTON, TOTALS		2,628,998	129,500	18,400	10,000	408,500	-	566,400
WINDHAM	12-A		-	-	-	37,000	-	37,000
WINDHAM	*		-	-	400	28,500	-	28,900
WINDHAM, TOTALS		198,125	-	-	400	65,500	-	65,900
WINDSOR	C-3		700	-	-	-	-	700
WINDSOR	*		2,000	4,600	1,000	8,400	-	16,000
WINDSOR, TOTALS		4,008,293	2,700	4,600	1,000	8,400	-	16,700
WOODFORD	*	227,124	-	-	-	19,300	-	** 19,300
WOODSTOCK	9-W		-	-	30,500	-	-	30,500
WOODSTOCK	*		-	10,500	-	25,000	-	35,500
WOODSTOCK, TOTALS		2,668,143	-	10,500	30,500	25,000	-	66,000
ESTIMATED MISCELLANEOUS	*		-	6,900	800	61,000	6,600	75,300
GRAND TOTAL		95,474,663	407,000	231,000	267,000	2,839,000	65,000	3,809,000

* IN COLUMN (2) IDENTIFIES TOWN LOSSES NOT SUBJECT TO CONTROL BY STUDIED RESERVOIR PLANS. NUMBERS AND LETTERS IN COLUMN REFER TO DAMAGE ZONES DESCRIBED IN TABLE XIV.

** NO INVESTIGATION.

COLUMN (3) GIVES TOTAL ASSESSED VALUATIONS FOR TOWNS, TAKEN FROM "1935 GRAND LIST VALUE" FROM "1936 VERMONT YEAR BOOK."

COLUMN (4) INCLUDES RESIDENTIAL, COMMERCIAL AND PUBLIC.

COLUMN (6) INCLUDES UTILITY.

TABLE XI

DIRECT FLOOD LOSSES - CONNECTICUT RIVER WATERSHED - 1938 FLOOD
STATE OF NEW HAMPSHIRE

SUMMARY OF DIRECT LOSSES AND ASSESSED VALUATIONS OF TOWNS SUSTAINING LOSSES.

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938: URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ACWORTH	*	$ 355,800	$ -	$ 4,300	$ -	$ 8,900	$ -	$**13,200
ALSTEAD	*	761,020	-	1,000	--	13,500	-	14,500
BATH	C-1		-	400	-	-	-	400
BATH	4-B		-	4,600	3,000	500	1,100	9,200
BATH, TOTALS		923,720	-	5,000	3,000	500	1,100	9,600
BENTON	*	168,480	-	-	-	1,100	-	1,100
BETHLEHEM	4-A		200	500	-	500	300	1,500
BETHLEHEM	4-Y		-	-	4,000	1,000	-	5,000
BETHLEHEM	*		11,500	1,500	-	10,000	-	23,000
BETHLEHEM, TOTALS		3,164,139	11,700	2,000	4,000	11,500	300	29,500
CANAAN	8-A		100	-	-	200	-	300
CANAAN	*		1,700	600	-	4,100	1,100	7,500
CANAAN, TOTALS		1,115,520	1,800	600	-	4,300	1,100	7,800
CARROLL	*		1,100	-	-	-	-	1,000
CARROLL	4-X		3,700	-	-	1,800	-	5,500
CARROLL, TOTALS		1,499,475	4,700	-	-	1,800	-	6,500
CHARLESTOWN	C-4		-	1,000	-	-	-	1,000
CHARLESTOWN	*		-	-	-	10,000	-	10,000
CHARLESTOWN, TOTALS		1,862,505	-	1,000	-	10,000	-	11,000
CHESTERFIELD	C-5		-	2,500	-	2,600	-	5,100
CHESTERFIELD	*		-	-	500	14,500	-	15,000
CHESTERFIELD, TOTALS		1,301,689	-	2,500	500	17,100	-	20,100
CLAREMONT	C-4		-	300	-	-	-	300
CLAREMONT	10-A		-	200	200	-	-	400
CLAREMONT	10-B		3,600	200	1,300	100	-	5,200
CLAREMONT	*		-	-	-	1,200	-	1,200
CLAREMONT, TOTALS		13,991,480	3,600	700	1,500	1,300	-	7,100
COLUMBIA	*	539,560	-	-	-	11,500	-	11,500
CORNISH	*	939,692	2,000	-	-	15,000	-	** 17,000
CROYDON	10-C		100	-	-	-	-	100
CROYDON	*		-	-	-	400	-	400
CROYDON, TOTALS		417,234	100	-	-	400	-	500
DALTON	*	439,514	5,000	-	-	4,000	3,000	12,000
DUBLIN	*	1,896,940	-	-	-	2,000	-	2,000

TABLE XI (CONTINUED)
STATE OF NEW HAMPSHIRE

TOWN	DAM-AGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938 URBAN	AGRI-CULTURE	INDUS-TRIAL	HIGH-WAY	RAIL-ROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
EASTON	*	$ 143,937	$ -	$ -	$ -	$ 2,000	$ -	$ 2,000
ENFIELD	8-A		100	-	200	1,100	1,000	2,400
ENFIELD	*		-	-	-	1,000	-	1,000
ENFIELD, TOTALS		1,317,843	100	-	200	2,100	1,000	3,400
FITZWILLIAM	*	837,920	-	-	-	10,500	11,200	21,700
FRANCONIA	4-Y		400	-	-	100	-	500
FRANCONIA	*		400	-	-	-	-	400
FRANCONIA, TOTALS		1,034,655	800	-	-	100	-	900
GILSUM	*	294,910	-	-	-	5,100	-	5,100
GRAFTON	*	405,803	-	2,500	-	10,900	-	** 13,400
GRANTHAM	10-C	219,775	-	-	-	900	-	900
HANOVER	C-2		-	-	-	3,200	-	3,200
HANOVER	*		-	-	-	3,200	-	3,200
HANOVER, TOTALS		5,503,389	-	-	-	6,400	-	6,400
HARRISVILLE	*	916,208	-	-	-	1,900	-	1,900
HAVERHILL	C-1		-	2,500	100	-	700	3,300
HAVERHILL	4-B		1,100	500	-	-	-	1,600
HAVERHILL	*		500	-	-	2,000	-	** 2,500
HAVERHILL, TOTALS		3,674,913	1,600	3,000	100	2,000	700	7,400
HINSDALE	C-5		400	-	-	1,000	3,000	4,400
HINSDALE	C-6		700	3,000	-	-	-	3,700
HINSDALE	14-F		600	-	5,700	1,500	1,200	9,000
HINSDALE	*		-	-	-	5,600	-	5,600
HINSDALE, TOTALS		3,391,675	1,700	3,000	5,700	8,100	4,200	22,700
JEFFERSON	*	934,409	-	-	-	19,000	1,000	** 20,000
KEENE	14-A		2,400	100	-	3,300	-	5,800
KEENE	14-B		100,600	16,000	103,200	3,700	21,000	244,500
KEENE	14-C		3,600	3,800	-	-	-	7,400
KEENE	14-M		500	1,100	400	-	-	2,000
KEENE	14-X		500	500	-	4,000	-	5,000
KEENE	*		1,200	-	-	17,000	-	18,200
KEENE, TOTALS		17,860,504	108,800	21,500	103,600	28,000	21,000	282,900
LANCASTER	*	2,958,654	-	-	-	5,000	-	** 5,000
LANDAFF	*	325,034	-	-	-	2,800	-	** 2,800
LANGDON	*	216,078	-	-	-	1,000	-	** 1,000
LEBANON	C-2		-	-	-	3,000	-	3,000
LEBANON	C-3		-	700	-	-	-	700
LEBANON	8-B		24,200	1,700	13,000	100	500	39,500
LEBANON	*		-	-	-	2,100	-	2,100
LEBANON, TOTALS		7,716,126	24,200	2,400	13,000	5,200	500	45,300

TABLE XI (CONTINUED)
STATE OF NEW HAMPSHIRE

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938 URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LEMPSTER	*	$ 237,479	$ -	$ -	$ -	$ 500	$ -	$ 500
LISBON	1-A		-	100	-	100	200	400
LISBON	4-B		5,000	900	-	3,500	100	9,500
LISBON	4-Y		-	400	-	500	-	900
LISBON, TOTALS		2,863,412	5,000	1,400	-	4,100	300	10,800
LITTLETON	4-A	4,915,309	-	2,800	700	-	-	3,500
LYMAN	*	330,915	-	-	-	1,100	-	** 1,100
LYME	*	794,183	-	-	-	5,800	-	** 5,800
MARLBORO	14-X		5,800	1,200	12,700	10,500	-	30,200
MARLBORO	*		-	-	-	27,200	-	27,200
MARLBORO, TOTALS		1,251,100	5,800	1,200	12,700	37,700	-	57,400
MARLOW	*	285,929	-	-	-	2,800	-	2,800
MONROE	*	9,066,891	-	-	-	1,000	-	1,000
NASH & SAWYER	4-X		500	-	-	-	-	500
NELSON	*	358,995	-	-	-	8,000	-	8,000
NEW LONDON	*	1,903,627	-	-	-	3,300	-	3,300
NEWPORT	10-W		1,200	1,700	400	100	-	3,400
NEWPORT	10-A		-	-	400	100	-	500
NEWPORT	*		-	-	-	1,100	-	1,100
NEWPORT, TOTALS		4,608,470	1,200	1,700	800	1,300	-	5,000
NORTHUMBERLAND	*	2,483,504	5,000	-	1,000	2,200	2,000	** 10,200
ORANGE	*	125,045	-	-	-	2,000	-	2,000
ORFORD	C-2		-	100	-	600	-	700
ORFORD	*		1,000	-	-	1,000	-	** 2,000
ORFORD, TOTALS		742,656	1,000	100	-	1,600	-	2,700
PIERMONT	C-2		-	2,600	-	-	-	2,600
PIERMONT	*		1,000	-	-	1,000	-	** 2,000
PIERMONT, TOTALS		667,290	1,000	2,600	-	1,000	-	4,600
PITTSBURG	*	2,566,702	-	-	-	3,000	-	** 3,000
PLAINFIELD	C-3		-	200	-	-	-	200
PLAINFIELD	*		-	-	-	2,000	-	** 2,000
PLAINFIELD, TOTALS		761,415	-	200	-	2,000	-	2,200
RICHMOND	*	286,249	-	-	-	9,400	-	9,400
RINDGE	*	1,119,145	-	-	-	5,000	5,700	10,700
ROXBURY	14-M		-	-	-	700	-	700
ROXBURY	*		-	-	-	5,200	-	5,200
ROXBURY, TOTALS		122,182	-	-	-	5,900	-	5,900

TABLE XI (CONTINUED)
STATE OF NEW HAMPSHIRE

TOWN (1)	DAMAGE ZONE (2)	ASSESSED VALUES 1935 (3)	DIRECT FLOOD LOSSES - SEPTEMBER 1938: URBAN (4)	AGRICULTURE (5)	INDUSTRIAL (6)	HIGHWAY (7)	RAILROAD (8)	TOTAL (9)
SPRINGFIELD	*	$ 419,557	$ -	$ -	$ -	$ 3,000	$ -	$** 3,000
STARK	*	342,908	-	-	-	5,000	-	** 5,000
STODDARD	*	442,575	-	-	-	2,200	-	2,200
STRATFORD	*	1,067,990	1,000	-	-	3,200	-	** 4,200
SULLIVAN	*	183,932	-	-	-	6,000	-	6,000
SUNAPEE	10-W		-	-	100	-	-	100
SUNAPEE	*		26,000	-	-	1,000	-	27,000
SUNAPEE, TOTALS		2,143,580	26,000	-	100	1,000	-	27,100
SURRY	*	362,547	-	-	-	800	-	800
SWANZEY	14-C		2,000	15,100	17,500	2,000	4,000	40,600
SWANZEY	*		-	-	-	8,200	-	8,200
SWANZEY		1,584,938	2,000	15,100	17,500	10,200	4,000	48,800
TROY	*	1,049,614	-	-	-	12,500	-	12,500
UNITY	*	360,290	-	-	-	500	-	500
WALPOLE	C-5	3,518,165	-	3,100	-	18,500	-	21,600
WARREN	*	554,624	-	-	-	2,000	-	2,000
WASHINGTON	*	441,113	500	-	1,000	9,000	-	10,500
WESTMORELAND	C-5		-	400	-	-	-	400
WESTMORELAND	*		1,000	1,000	-	2,000	14,300	** 18,300
WESTMORELAND, TOTALS		552,795	1,000	1,400	-	2,000	14,300	18,700
WINCHESTER	14-C		50,400	17,200	46,900	1,500	2,500	118,500
WINCHESTER	14-F		-	-	13,000	8,000	-	21,000
WINCHESTER	*		-	-	-	7,100	1,500	8,600
WINCHESTER, TOTALS		2,133,310	50,400	17,200	59,900	16,600	4,000	148,100
ESTIMATED MISCELLANEOUS			2,500	9,700	14,700	14,900	15,600	57,400
GRAND TOTALS		127,777,037	269,000	106,000	240,000	419,000	91,000	1,125,000

* IN COLUMN (2) IDENTIFIES TOWN LOSSES NOT SUBJECT TO CONTROL BY STUDIED RESERVOIR PLANS. NUMBERS AND LETTERS IN COLUMN REFER TO DAMAGE ZONES DESCRIBED IN TABLE XIV.

** NO INVESTIGATION.

COLUMN (3) GIVES TOTAL ASSESSED VALUATIONS FOR TOWNS TAKEN FROM REPORT N.H. TAX COMMISSION FOR YEAR OF 1935 WHICH INCLUDES ALL ASSESSABLE PROPERTY.

COLUMN (4) INCLUDES RESIDENTIAL, COMMERCIAL AND PUBLIC.

COLUMN (6) INCLUDES UTILITY.

TABLE XII
DIRECT FLOOD LOSSES - CONNECTICUT RIVER WATERSHED - 1938 FLOOD
STATE OF MASSACHUSETTS

SUMMARY OF DIRECT LOSSES AND ASSESSED VALUATIONS
OF TOWNS SUSTAINING LOSSES.

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938: URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AGAWAM	C-8	$ 9,736,254	$ 29,500	$ 6,100	$ -	$ 12,000	$ -	47,600
AMHERST	*	10,144,491	-	9,000	-	1,000	-	10,000
ASHBURNHAM	*	1,764,207	-	-	-	37,300	3,900	41,200
ASHFIELD	*	1,457,508	3,500	-	-	73,000	-	76,500
ATHOL	15-E		-	-	86,900	2,000	22,800	111,700
ATHOL	15-G		274,900	32,600	156,100	21,000	27,200	511,800
ATHOL	15-F		-	-	-	3,000	-	3,000
ATHOL	*		-	-	-	50,900	7,200	58,100
ATHOL TOTALS		11,806,947	274,900	32,600	243,000	76,900	57,200	684,600
BARRE	22-A		-	-	1,300	-	1,000	2,300
BARRE	22-B		50,500	1,400	105,500	54,000	18,000	229,400
BARRE	*		-	2,000	21,800	122,500	-	146,300
BARRE TOTALS		3,186,361	50,500	3,400	128,600	176,500	19,000	378,000
BECKET	18-W		-	-	100	100	1,000	1,200
BECKET	*	-	-	-	-	12,700	-	12,700
BECKET TOTALS		1,121,823	-	-	100	12,800	1,000	13,900
BELCHERTOWN	17-A		-	1,900	-	-	-	1,900
BELCHERTOWN	*		-	-	-	16,500	500	17,000
BELCHERTOWN TOTALS		1,573,920	-	1,900	-	16,500	500	18,900
BLANDFORD	*	1,300,232	-	-	-	10,500	-	10,500
BRIMFIELD	21-B		1,100	3,300	-	16,000	-	20,400
BRIMFIELD	*		-	-	-	65,300	-	65,300
BRIMFIELD TOTALS		963,058	1,100	3,300	-	81,300	-	85,700
BROOKFIELD	21-A	1,417,098	23,100	6,800	8,900	10,000	1,500	50,300
BUCKLAND	16-V	3,096,637	33,300	-	61,500	221,000	51,000	366,800
CHARLEMONT	16-U	1,204,352	39,400	14,400	106,900	221,900	78,500	461,100
CHESTER	18-X		600	-	-	32,000	-	32,600
CHESTER	18-W		14,000	1,600	6,000	9,700	3,100	34,400
CHESTER	*		-	-	-	28,800	-	28,800
CHESTER TOTALS		1,458,554	14,600	1,600	6,000	70,500	3,100	95,800
CHESTERFIELD	18-V	680,450	100	-	3,000	2,000	-	5,100
CHICOPEE	C-8		245,000	-	125,000	25,000	5,000	400,000
CHICOPEE	17-B		39,000	14,200	273,700	223,200	-	550,100
CHICOPEE TOTALS		42,446,529	284,000	14,200	398,700	248,200	5,000	950,100
COLRAIN	16-X	1,548,080	68,800	31,700	18,100	500,000	-	618,600
CONWAY	*	1,007,778	8,000	3,000	69,000	208,000	-	288,000
CUMMINGTON	18-V	557,488	14,100	500	-	330,400	-	345,000

STATE OF MASSACHUSETTS

TOWN (1)	DAMAGE ZONE (2)	ASSESSED VALUES 1935 (3)	DIRECT FLOOD LOSSES - SEPTEMBER 1938 URBAN (4)	AGRICULTURE (5)	INDUSTRIAL (6)	HIGHWAY (7)	RAILROAD (8)	TOTAL (9)
DEERFIELD	C-7	$	$ 5,800	$15,000	$ 2,900	$ 4,000	$ -	$ 27,700
DEERFIELD	16-V		-	70,700	-	-	4,400	75,100
DEERFIELD TOTALS		4,083,436	5,800	85,700	2,900	4,000	4,400	102,800
EAST BROOKFIELD	21-A		-	1,300	-	4,000	48,500	53,800
EAST BROOKFIELD	*		-	-	91,900	15,600	-	107,500
EAST BROOKFIELD TOTALS		1,159,871	-	1,300	91,900	19,600	48,500	161,300
EASTHAMPTON	C-7		-	-	16,600	2,000	500	19,100
EASTHAMPTON	*		5,000	2,000	5,000	54,100	5,000	71,100
EASTHAMPTON TOTALS		10,497,268	5,000	2,000	21,600	56,100	5,500	90,200
ERVING	15-H		400	800	103,900	23,000	160,000	288,100
ERVING	*		-	-	-	3,000	-	3,000
ERVING TOTALS		2,251,699	400	800	103,900	26,000	160,000	291,100
FLORIDA	16-U		-	-	-	41,000	9,000	50,000
FLORIDA	*		-	-	-	144,000	-	144,000
FLORIDA TOTALS		1,674,958	-	-	-	185,000	9,000	194,000
GARDNER	*	24,071,973	-	-	-	61,800	6,700	68,500
GILL	*	935,708	-	500	-	3,700	-	4,200
GRANBY	*	1,005,790	-	-	-	2,000	-	** 2,000
GRANVILLE	*	2,015,693	-	-	-	4,000	-	** 4,000
GREENFIELD	16-W		2,700	-	1,700	10,000	-	14,400
GREENFIELD	C-7		8,000	-	27,200	-	-	35,200
GREENFIELD	*		-	-	-	7,500	-	7,500
GREENFIELD TOTALS		29,813,607	10,700	-	28,900	17,500	-	57,100
HADLEY	C-7	3,028,755	90,000	121,000	-	16,000	3,000	230,000
HARDWICK	22-B		7,400	4,600	321,900	79,000	13,000	425,900
HARDWICK	*		600	-	300	60,000	-	60,900
HARDWICK TOTALS		1,833,293	8,000	4,600	322,200	139,000	13,000	486,800
HATFIELD	C-7		95,000	152,000	3,000	20,000	-	270,000
HATFIELD	*		1,000	2,000	-	18,000	2,000	23,000
HATFIELD TOTALS		2,731,693	96,000	154,000	3,000	38,000	2,000	293,000
HAWLEY	*	250,033	2,600	2,600	600	281,000	-	286,800
HEATH	*	502,618	1,000	5,000	-	81,000	-	87,000
HOLYOKE	C-7	90,898,212	50,000	-	300,000	14,000	36,000	400,000
HUBBARDSTON	*	781,981	1,000	-	7,500	79,000	-	87,500
HUNTINGTON	18-A		1,700	400	1,600	2,800	500	7,000
HUNTINGTON	18-B		3,000	-	-	5,000	-	8,000
HUNTINGTON	18-V		400	1,200	-	3,400	-	5,000
HUNTINGTON	18-W		13,200	500	24,000	15,000	15,000	67,700
HUNTINGTON	18-X		-	-	-	800	-	800
HUNTINGTON TOTALS		1,013,236	18,300	2,100	25,600	27,000	15,500	88,500
LEVERETT	*	506,057	-	-	500	4,000	-	** 4,500
LONGMEADOW	C-8	13,105,622	300	3,000	-	200	-	3,500

TABLE XII (CONTINUED)

STATE OF MASSACHUSETTS

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938					
			URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ludlow	17-B	$	$ 19,500	$ 7,100	$ 58,100	$ 54,000	$ 10,000	$148,700
Ludlow	*		-	-	-	8,000	-	8,000
Ludlow Totals		8,531,062	19,500	7,100	58,100	62,000	10,000	156,700
Middlefield	18-W		-	-	-	-	5,400	5,400
Middlefield	18-X		-	300	-	6,500	-	6,800
Middlefield	*		-	-	-	12,800	-	12,800
Middlefield Totals		362,749	-	300	-	19,300	5,400	25,000
Monroe	16-U	1,262,899	-	-	2,800	36,000	-	38,800
Monson	21-B		28,500	300	-	5,000	4,200	38,000
Monson	*		-	-	-	124,600	1,800	126,400
Monson Totals		3,599,617	28,500	300	-	129,600	6,000	164,400
Montague	15-H'		1,200	-	-	18,600	187,800	207,600
Montague	C-7		6,000	4,200	47,300	15,000	-	72,500
Montague	*		1,000	1,000	-	5,000	-	** 7,000
Montague Totals		10,397,227	8,200	5,200	47,300	38,600	187,800	287,100
Montgomery	18-B		-	-	-	-	10,000	10,000
Montgomery	*		-	-	-	15,000	-	15,000
Montgomery Totals		301,711	-	-	-	15,000	10,000	25,000
New Braintree	22-B		-	6,300	-	24,000	5,000	35,300
New Braintree	*		-	-	-	16,500	-	16,500
New Braintree Totals		522,926	-	6,300	-	40,500	5,000	51,800
New Salem	*	476,257	-	-	-	4,000	-	** 4,000
Northampton	C-7		57,600	60,000	129,000	15,500	7,900	270,000
Northampton	*		10,000	1,000	25,000	10,000	-	**46,000
Northampton Totals		28,352,152	67,600	61,000	154,000	25,500	7,900	316,000
North Brookfield	*	2,266,000	-	-	-	33,300	-	33,300
Northfield	*	2,044,050	-	-	-	6,000	-	6,000
Oakham	*	458,000	-	-	-	77,900	10,000	87,900
Orange	15-G'		276,300	13,400	373,800	24,800	36,200	724,500
Orange	*		-	-	-	22,500	-	22,500
Orange Totals		5,257,129	276,300	13,400	373,800	47,300	36,200	747,000
Palmer	22-B		41,200	29,500	159,700	8,000	14,300	252,700
Palmer	21-B		10,100	2,400	50,200	114,000	1,000	177,700
Palmer	17-A		-	1,100	16,800	-	-	17,900
Palmer	17-B		151,400	5,500	75,000	8,200	16,000	256,100
Palmer	*		-	1,000	-	15,000	-	16,000
Palmer Totals		8,564,981	202,700	39,500	301,700	145,200	31,300	720,400

TABLE XII (CONTINUED)

STATE OF MASSACHUSETTS

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938 URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PERU	*	$ 312,590	$ -	$ -	$ -	$ 1,000	$ -	$ 1,000
PETERSHAM	*	1,447,000	-	-	-	42,500	-	42,500
PHILLIPSTON	*	401,220	-	-	-	6,000	30,000	36,000
ROWE	16-U		-	-	13,000	48,000	1,000	62,000
ROWE	*		-	-	-	78,000	-	78,000
ROWE TOTALS		776,432	-	-	13,000	126,000	1,000	140,000
ROYALSTON	15-C		-	13,500	-	-	-	13,500
ROYALSTON	15-E		7,800	-	95,500	9,000	1,800	114,100
ROYALSTON	*		-	-	-	40,900	-	40,900
ROYALSTON TOTALS		856,710	7,800	13,500	95,500	49,900	1,800	168,500
RUSSELL	18-B		5,200	300	422,100	3,000	24,000	454,600
RUSSELL	*		-	-	-	4,500	15,000	19,500
RUSSELL TOTALS		4,464,829	5,200	300	422,100	7,500	39,000	474,100
RUTLAND	*	1,352,257	-	-	-	5,300	-	5,300
SANDISFIELD	16-U		-	-	700	4,100	-	4,800
SANDISFIELD	*		-	-	-	1,000	-	1,000
SANDISFIELD		701,124	-	-	700	5,100	-	5,800
SAVOY	*	327,685	1,000	-	-	60,800	-	61,800
SHELBURNE	16-V		24,700	-	17,000	-	54,000	95,700
SHELBURNE	16-X		7,600	-	-	-	-	7,600
SHELBURNE TOTALS		3,021,212	32,300	-	17,000	-	54,000	103,300
SHUTESBURY	*	453,636	-	-	-	1,000	-	** 1,000
SOUTH HADLEY	C-7	9,033,148	14,600	-	-	400	-	15,000
SOUTHAMPTON	*	1,006,746	-	-	-	500	-	** 500
SOUTHWICK	*	2,250,633	2,000	-	4,500	2,500	-	** 9,000
SPENCER	21-A		-	700	-	-	-	700
SPENCER	*		-	-	-	25,200	2,000	27,200
SPENCER TOTALS		4,539,024	-	700	-	25,200	2,000	27,900
SPRINGFIELD	17-B		-	-	59,000	68,000	-	127,000
SPRINGFIELD	C-8		305,000	-	200,000	50,000	5,000	560,000
SPRINGFIELD TOTALS		306,672,889	305,000	-	259,000	118,000	5,000	687,000
SUNDERLAND	C-7	1,210,785	1,500	62,000	-	2,500	-	66,000
TEMPLETON	15-X		38,800	5,800	229,200	105,300	165,200	544,300
TEMPLETON	*		-	-	-	109,900	124,300	234,200
TEMPLETON TOTALS		3,306,220	38,800	5,800	229,200	215,200	289,500	778,500
TOLLAND	19-U	402,469	10,000	-	-	16,300	-	26,300

TABLE XII (CONTINUED)

STATE OF MASSACHUSETTS

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938 URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
WARE	22-B	$ -	$ 327,000	$32,000	$ 316,100	$ 130,800	$ 116,200	$ 922,100
WARE	*		8,400	2,000	-	23,200	-	33,600
WARE TOTALS		5,421,078	335,400	34,000	316,100	154,000	116,200	955,700
WARREN	21-B		6,600	4,100	59,800	40,100	10,000	120,600
WARREN	*		4,000	-	-	56,300	-	60,300
WARREN TOTALS		2,599,728	10,600	4,100	59,800	96,400	10,000	180,900
WARWICK	*	382,963	-	-	-	6,000	-	6,000
WENDELL	15-G*		-	-	-	-	6,700	6,700
WENDELL	15-H*		1,300	400	193,000	-	179,600	374,300
WENDELL	*		-	-	-	9,200	-	9,200
WENDELL TOTALS		1,014,141	1,300	400	193,000	9,200	186,300	390,200
WASHINGTON	*	292,190	-	-	-	2,500	- **	2,500
WEST BROOKFIELD	21-A		500	5,700	1,200	-	7,500	14,900
WEST BROOKFIELD	21-B		-	1,400	-	-	-	1,400
WEST BROOKFIELD	*		-	200	-	47,900	-	48,100
WEST BROOKFIELD TOTALS		1,470,146	500	7,300	1,200	47,900	7,500	64,400
WESTFIELD	18-B		114,300	10,000	5,600	25,100	-	155,000
WESTFIELD	18-C		6,100	17,000	-	18,300	-	41,400
WESTFIELD TOTALS		19,874,158	120,400	27,000	5,600	43,400	-	196,400
WESTHAMPTON	*	411,400	-	-	-	1,000	- **	1,000
WEST SPRINGFIELD	C-8		115,000	55,000	-	30,000	-	200,000
WEST SPRINGFIELD	18-C		4,500	-	1,200	3,200	1,100	10,000
WEST SPRINGFIELD TOTALS		26,244,480	119,500	55,000	1,200	33,200	1,100	210,000
WHATELY	C-7	1,158,881	-	40,000	-	2,000	-	42,000
WILBRAHAM	17-B		400	200	142,700	200,000	-	343,300
WILBRAHAM	*		-	-	4,000	500	-	4,500
WILBRAHAM TOTALS		3,109,577	400	200	146,700	200,500	-	347,800
WINCHENDON	15-C		20,700	8,500	59,000	36,100	12,600	136,900
WINCHENDON	15-D		100	900	-	3,900	-	4,900
WINCHENDON	*		2,900	200	1,500	86,000	38,100	128,700
WINCHENDON TOTALS		5,741,929	23,700	9,600	60,500	126,000	50,700	270,500
WINDSOR	*	504,895	-	-	-	14,500	-	14,500
WORTHINGTON	18-V		-	-	-	1,000	-	1,000
WORTHINGTON	18-X		-	100	-	1,600	-	1,700
WORTHINGTON	*		-	-	-	23,500	-	23,500
WORTHINGTON TOTALS		671,190	-	100	-	26,100	-	26,200
ESTIMATED MISCELLANEOUS			10,200	800	19,800	10,700	-	41,500
GRAND TOTAL		772,429,395	2,777,000	905,000	4,735,000	5,508,000	1,628,000	15,553,000

* IN COLUMN (2) IDENTIFIES TOWN LOSSES NOT SUBJECT TO CONTROL BY STUDIED RESERVOIR PLANS. NUMBERS AND LETTERS IN COLUMN REFER TO DAMAGE ZONES DESCRIBED IN TABLE XIV.

** NO INVESTIGATION.

COLUMN (3) GIVES TOTAL ASSESSED VALUATIONS FOR TOWNS TAKEN FROM MANUAL OF THE GENERAL COURT, 1935-1936 (STATE OF MASSACHUSETTS).

COLUMN (4) INCLUDES RESIDENTIAL, COMMERCIAL AND PUBLIC.

COLUMN (6) INCLUDES UTILITY.

TABLE XIII

DIRECT FLOOD LOSSES - CONNECTICUT RIVER WATERSHED - 1938 FLOOD

STATE OF CONNECTICUT

SUMMARY OF DIRECT LOSSES AND ASSESSED VALUATIONS
OF TOWNS SUSTAINING LOSSES.

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938 URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AVON	19-X	$ 3,378,731	$ 900	$19,800	$ -	$ -	$ -	$ 20,700
BARKHAMSTED	19-V		8,600	-	16,000	11,000	-	35,600
BARKHAMSTED	19-Y		600	-	500	-	-	1,100
BARKHAMSTED	*		-	-	-	2,000	-	2,000
BARKHAMSTED TOTALS		1,140,873	9,200	-	16,500	13,000	-	38,700
BRISTOL	*	51,064,425	-	-	-	5,700	-	5,700
BURLINGTON	19-W		8,900	-	-	-	-	8,900
BURLINGTON			-	-	-	7,000	-	7,000
BURLINGTON TOTALS		989,465	8,900	-	-	12,700	-	15,900
CANTON	19-W		14,000	9,600	44,000	98,500	-	166,100
CANTON	*		-	-	-	15,000	-	15,000
CANTON TOTALS		3,373,176	14,000	9,600	44,000	113,500	-	181,100
CHESTER	C-10	1,403,003	-	800	-	700	700	** 2,200
COLEBROOK	19-V		37,400	-	-	9,700	-	47,100
COLEBROOK	19-Y		-	800	-	-	-	800
COLEBROOK TOTALS		1,289,975	37,400	800	-	9,700	-	47,900
CROMWELL	C-10	3,703,494	30,000	55,000	17,000	9,800	500	112,300
EAST GRANBY	*		-	-	-	3,000	-	3,000
EAST GRANBY	19-X		500	1,500	800	-	-	2,800
EAST GRANBY TOTALS		1,789,043	500	1,500	800	3,000	-	5,800
EAST HADDAM	C-10		17,000	15,000	5,000	11,000	-	48,000
EAST HADDAM	*		2,000	2,000	15,000	5,000	-	** 24,000
EAST HADDAM TOTALS		2,874,080	19,000	17,000	20,000	16,000	-	72,000
EAST HAMPTON	*		-	-	1,000	11,000	-	12,000
EAST HAMPTON	C-10		-	500	-	2,800	-	** 3,300
EAST HAMPTON TOTALS		3,844,268	-	500	1,000	13,800	-	15,300
EAST HARTFORD	C-10		526,200	40,200	280,600	41,900	8,300	** 897,200
EAST HARTFORD	*		60,000	1,000	25,000	25,000	-	111,000
EAST HARTFORD TOTALS		35,659,887	586,200	41,200	305,600	66,900	8,300	1,008,200
EAST WINDSOR	C-9		24,300	16,000	4,000	4,300	-	** 48,600
EAST WINDSOR	*		5,000	2,000	-	18,000	-	** 25,000
EAST WINDSOR TOTALS		4,156,915	29,300	18,000	4,000	22,300	-	73,600

TABLE XIII (Continued)

STATE OF CONNECTICUT

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES - SEPTEMBER 1938 URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Enfield	*	$	$ -	$ -	$ -	$ 7,000	$ -	** $7,000
Enfield	C-9		1,400	2,000	2,000	6,000	1,000	** 12,400
Enfield Totals		19,374,633	1,400	2,000	2,000	13,000	1,000	19,400
Essex	*		5,000	-	-	1,000	-	** 6,000
Essex	C-10		1,000	-	26,500	-	-	** 27,500
Essex Totals		4,098,693	6,000	-	26,500	1,000	-	33,500
Farmington	19-W		47,400	8,000	44,600	-	23,000	123,000
Farmington	19-X		8,700	12,900	300	-	-	21,900
Farmington	*		-	-	-	97,500	-	97,500
Farmington Totals		7,914,004	56,100	20,900	44,900	97,500	23,000	242,400
Glastonbury	C-10		42,000	7,000	1,000	99,000	-	149,000
Glastonbury	*		1,000	-	10,000	20,000	-	31,000
Glastonbury Totals		8,846,911	43,000	7,000	11,000	119,000	-	180,000
Haddam	*		-	15,000	23,300	27,000	10,000	75,300
Haddam	C-10		-	16,500	-	500	1,000	** 18,000
Haddam Totals		1,883,090	-	31,500	23,300	27,500	11,000	93,300
Hartford	C-10		491,000	3,000	638,000	47,000	21,000	1,200,000
Hartford	*		-	-	10,000	15,000	-	** 25,000
Hartford Totals		352,319,419	491,000	3,000	648,000	62,000	21,000	1,225,000
Hartland	19-V	593,296	500	-	-	32,600	-	33,100
Lyme	C-10	1,526,274	3,400	-	-	500	-	** 3,900
Middletown	C-10		140,000	-	230,000	125,000	5,000	500,000
Middletown	*		7,000	-	-	21,000	10,000	** 38,000
Middletown Totals		34,215,609	147,000	-	230,000	146,000	15,000	538,000
New Hartford	19-V		31,900	14,000	106,200	-	200	152,300
New Hartford	*		-	-	-	10,000	-	10,000
New Hartford Totals		2,442,408	31,900	14,000	106,200	10,000	200	162,300
Portland	*		-	3,000	-	7,000	-	10,000
Portland	C-10		3,000	30,000	100,000	15,000	-	148,000
Portland Totals		5,955,769	3,000	33,000	100,000	22,000	-	158,000
Rocky Hill	C-10	3,070,772	-	2,000	22,000	200	1,000	25,200
Saybrook	C-10		100	-	100	1,400	-	** 1,600
Saybrook	*		2,000	-	-	5,000	-	** 7,000
Saybrook Totals		2,603,123	2,100	-	100	6,400	-	8,600
Simsbury	19-X		17,300	155,900	10,900	600	400	185,100
Simsbury	*		-	-	-	5,000	-	5,000
Simsbury Totals		8,133,916	17,300	155,900	10,900	5,600	400	190,100

TABLE XIII (Continued)

STATE OF CONNECTICUT

TOWN	DAMAGE ZONE	ASSESSED VALUES 1935	DIRECT FLOOD LOSSES – SEPTEMBER 1938: URBAN	AGRICULTURE	INDUSTRIAL	HIGHWAY	RAILROAD	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
South Windsor	C-9	$	$ -	$11,000	$ -	$ 2,200	$ -	**$13,200
South Windsor	C-10		5,000	50,000	-	5,000	-	** 60,000
South Windsor	*		1,000	2,000	-	10,000	-	** 13,000
South Windsor Totals		3,539,869	6,000	63,000	-	17,200	-	86,200
Suffield	*		-	-	-	5,000	-	** 5,000
Suffield	C-9		-	1,000	-	-	-	** 1,000
Suffield Totals		7,297,497	-	1,000	-	5,000	-	6,000
Wethersfield	C-10	12,329,078	4,500	-	14,500	500	-	19,500
Winchester	19-Y	14,074,684	71,000	900	5,900	25,800	3,000	106,600
Windsor	C-9		-	6,000	-	1,000	-	7,000
Windsor	C-10		23,400	9,500	68,000	700	2,400	104,000
Windsor	19-X		2,700	160,100	1,800	-	7,500	172,100
Windsor Totals		14,440,687	26,100	175,600	69,800	700	2,400	283,100
Windsor Locks	C-9	5,608,343	40,300	7,000	48,000	100	-	95,400
TOTAL (Connecticut Towns)		624,935,410	1,686,000	681,000	1,772,000	875,000	95,000	5,109,000

* In Column (2) identifies town losses not subject to control by studied reservoir plans, numbers and letters in column refer to damage zones described in Table XIV.

** No investigation.

Column (3) gives total assessed valuations for towns, taken from 1935 Grand List Values from "Connecticut State Register and Manual, 1936."

Column (4) includes residential, commercial and public.

Column (6) includes utility.

high-type farm land, were flooded. Existing levees along the Mill River at Northampton were sandbagged to protect successfully a portion of the town, but other unprotected areas, including approximately 70 dwellings, 750 acres of cultivated land, a few industries, fair grounds, and an airport, were flooded. Holyoke sustained only moderate damage. The railroad right-of-way at the west abutment of Holyoke Dam was sandbagged to prevent overflow of the canal system into the city. The local "Springdale" levee, south of the city, gave protection, although seepage through and under the earth embankment was so great that the pumping station could not evacuate the water and caused sewer back-up to flood basements and low-lying areas. The levee is poorly constructed, and the foundation consists of fine sand in a loose state of compaction, making the levee unreliable as protection for the area. Local levees at Chicopee were overtopped by several feet, resulting in the inundation of a large residential and industrial area which includes approximately 200 homes, 6 industries, 2 power stations, and a number of commercial establishments. Above the North End Bridge of Springfield, the Brightwood area was protected by a local levee which had been raised after the 1936 flood, although several hundred dwellings had been evacuated and precautions taken by the important industries in the area in anticipation of failure of the levee. The south end of the city was flooded, much as in 1936, and large commercial and residential areas, including 800 houses, were inundated. The main center of West Springfield, where direct losses of $3,045,000 had been sustained in 1936, was protected by partially completed levees, although extensive seepage along with a partial break very nearly inundated the area. Approximately 30 houses and 640 acres of market garden land were flooded in the Riverdale area of West Springfield, which remains without protection. In Connecticut, Hartford sustained large losses, although not so great as in 1936, because the area south of the Park

River remained protected by the partially enlarged Clark and Colt Dikes supplemented by sand bags. Direct losses in Hartford totaled approximately $1,200,000, compared with $7,660,000 in 1936 when the crest was 2-1/2 feet higher. East Hartford, Portland, and Middletown and the other towns in Connecticut suffered considerably, and sustained losses similar to those of 1936. Although the flood crested only a few feet below that of 1936, damage in the seven major damage centers of Massachusetts and Connecticut totaled approximately $4,000,000 in 1938, compared with $19,000,000 in 1936. The lesser damage in 1938 is partly due to the difference of two to three feet in flood stage, but principally due to: (1) savings of approximately $6,000,000 by levees partly completed by the U. S. Engineer Department, (2) improved flood warnings and emergency protective measures, and (3) absence of ice.

3. UPPER TRIBUTARY STREAMS. - The flood of September 1938 was not of particular importance on tributary streams above White River Junction, Vermont. On the Passumpsic, Stevens, Wells, Waits, and Ompompanoosuc Rivers in Vermont, crest stages were many feet below the record stages of 1927, and generally somewhat below the 1936 stage. Damage reported was chiefly to highways and crop lands. On the Ammonoosuc and on the other tributary streams in upper New Hampshire, stages were also below those of 1927, and about the same as those of 1936. Damage was considerably less than in 1936, because bridges and roads affected in 1936 were considerably improved in making repairs, and because no ice was in the rivers. In the Ammonoosuc River Basin direct losses of 1938 totaled $64,000, with principal damage occurring in Franconia, Littleton, Lisbon, and Woodsville.

4. WHITE RIVER, VERMONT. - The flood of 1938 equalled the flood of 1927 near the headwaters of the White River, but in the lower valley it was 10 to 12 feet below the crest of 1927 and several feet below the

crest of 1936. Direct losses totaled approximately $308,000. Damage was not so severe as might be expected from the magnitude of the flood, nor was there any loss of life in 1938, although 9 lives had been lost in the flood of 1927, and 2 lives lost in the flood of 1936. Main highways were washed out in several places and remained closed for a week, and railroad service was suspended 4 days. The villages of Bethel and Randolph were the major centers of damage. Bethel, located at the confluence of the Third Branch with the main river, sustained direct losses of only $68,000, in contrast to losses of approximately $1,000,000 experienced in 1927. Although the business district of Randolph is located high above Ayers Brook and the Third Branch, a low residential area of twenty houses was flooded. Small losses were sustained in the vicinity of Gaysville, where washout of a portion of the village center in 1927 had resulted in damage of over $400,000. There were no substantial losses in 1938 on the lower White River.

5. <u>MASCOMA RIVER, NEW HAMPSHIRE.</u> - The flood of September 1938 was about equal to the flood of 1927 and was slightly smaller then the record flood of March 1936. Direct losses for the flood of 1938 totaled $56,600. The flood damaged about 66 houses, 64 commercial establishments, 6 industries, and 2 power utilities. Railroad and main highways were closed for a very few days, due to flooding and washout. The principal losses occurred to houses, stores, and industries at Lebanon. A serious overflow and washout in the town was prevented by sandbag protection.

6. <u>OTTAUQUECHEE RIVER, VERMONT.</u> - The flood of September 1938 was the major flood of record on the Ottauquechee River, although it caused less damage than the flood of November 1927, due mainly to the fact that highway losses were reduced by improvements in the location and construction of highways and bridges after 1927. Total direct losses amounted to $280,000, compared with $532,000 in 1927. Considerable

damage to bridges on small streams occurred in 1938; 35 structures were reported as destroyed by the high water. Most of the valley suffered loss of the regular power and water supply for periods varying from one to three weeks. Damage on the main river was distributed equally among the villages of Bridgewater, West Woodstock, and Quechee. In each of these localities the principal industry sustained much of the losses, and damage to highways and a few dwellings make up the remainder.

7. SUGAR RIVER, NEW HAMPSHIRE. - The flood of 1938 was nearly equal to the record flood of 1936, but losses were considerably less, due to individual protective measures and improved repair of highways after 1936. Direct losses totaled approximately $40,000, with principal losses occurring at Newport and Claremont, and to cottages on Lake Sunapee. About 114 homes, 23 stores, and 12 industries, and 95 acres of cultivated land were flooded.

8. BLACK RIVER, VERMONT. - The flood of September 1938 caused damage of $398,000, and exceeded by approximately one foot the flood of 1927 which had caused direct losses of $716,000. The smaller losses in 1938 are due to the fact that much of the urban damage of 1927 was caused by destruction of property, as in the washout of dwellings along the main street at Cavendish Gorge. The towns of Ludlow and Springfield were the major centers of damage in 1938. At Ludlow, Vermont, 150 houses, 30 stores, and 5 woolen and other mills were damaged by the Black River and Jewell Brook, and direct losses of $204,200 were sustained. The industries of Springfield, Vermont, are located directly on the banks of the river. These industries sustained damage in 1938, with the exception of one plant which built a flood wall after the flood of 1927. About 40 houses and stores in Springfield were also affected, although the main residential section is located high above the river.

9. <u>WEST RIVER, VERMONT</u>. - Direct losses of 1938 totaled $823,000, of which approximately $688,000 damage was to highways. The peak exceeded the crests of 1927 and 1936 by 2 to 4 feet. No lives were lost due to this flood, although there was one lost in the flood of 1936. The basin is largely rural in character, with no important industrial developments, although 9 lumber mills, a power station, and 90 houses and stores were damaged. Highway travel was disrupted for a long period by the wrecking of approximately 70 bridges and washout of several miles of roadway. The communities most severely damaged were the villages of South Londonderry, Londonderry, and Weston. The village of Weston sustained considerable damage as it is located at one level. An area including 60 houses, a hotel, and a lumber plant was flooded 6 feet deep when a mill dam and concrete bridge were wrecked. At Londonderry and South Londonderry, smaller residential and commercial groups and a few industries were damaged. Other villages on small streams sustained considerable damage. These include the villages of South Newfane and East Dover on the Rock River, the village of Newfane on Wardsboro Brook, West Townshend on Tannery Brook, and the village of Jamaica on Ball Mountain Brook.

10. <u>ASHUELOT RIVER, NEW HAMPSHIRE</u>. - The flood of September 1938 exceeded the previous maximum flood of record, which occurred in March 1936, by approximately one foot. Direct losses totaled $613,000. Over 1200 families were forced from their houses, and 150 commercial and industrial properties were damaged. Railroad and highway travel on the main routes that pass through the watershed were interrupted for two weeks. Keene, New Hampshire, is the only large city in the watershed and was the principal center of damage. Keene has been built on the natural flood plain of the river, near the junction of Minnewawa Brook, Otter Brook, and the South Branch, which all combine to back up or over-

flow the industrial and residential property of the city. Below Keene, losses occur at West Swanzey, where one industry and several houses and farms were affected. The main commercial center, the two main industries, and outlying farm lands in Winchester were severely flooded. Below Winchester, damage was chiefly to farms and highways. On the minor tributaries and near the headwaters damage was principally to highways.

11. MILLERS RIVER, MASSACHUSETTS. - The peak flood stages of September 1938 were record stages on the Millers River. Previous maximum stages of March 1936 were exceeded by 3 to 5 feet. Total damage amounted to $3,728,000 and a loss of one life, compared with $2,597,000 in 1936. Failure of 8 dams and flooding or destruction of 4 power stations added to the intensity of flood conditions. Several miles of main highway and bridges were wrecked. Nearly 1400 families were forced from their homes. Two hundred stores and 60 industrial plants were flooded, some over the second floor level. Above Winchendon and on the smaller tributary streams, damage was principally to highways and railroads. A through express train was derailed there and passengers stranded. The new dams at Winchendon, built after the 1936 flood, suffered no damage, but several industrial buildings below were wrecked, and piled lumber was carried away to add to the troubles downstream. The water rushed through the village of Waterville, washing out the main street to a depth of two to three feet, flooding about 25 houses, and wrecking or removing from their foundations 8 or 10 more dwellings. At Winchendon Springs one hundred families evacuated their homes in anticipation of failure of two large reservoirs when a dam abutment was partially washed out. At South Royalston a large wood-working plant was damaged; the dam was washed around, gate-house and power station were wrecked, portions of the main buildings were wrecked, and piled lumber was washed away. Another major damage center was the Town of Athol, where seven large industrial

plants sustained heavy losses and a total number of 350 apartment houses, dwellings, and stores were flooded from 6 to 12 feet deep. The town was isolated for several days. Direct losses of $684,600 were sustained in Athol. Orange was another major center of damage with direct losses of $747,000. About 15 industrial plants and 550 houses and stores were flooded, several being washed completely away. Below Orange the flood wrecked a large dam and power station at Wendell Depot, and a smaller station at Erving. Many other industries and farm lands were also damaged.

12. DEERFIELD RIVER, VERMONT AND MASSACHUSETTS. - Direct losses of $4,108,000 and a loss of one life resulted from the flood of September 1938 in the Deerfield River Basin. The peak stage exceeded the crest stage of 1936 by approximately 5 feet and exceeded that of 1927 by an even greater amount. Discharge and damage were particularly great on the uncontrolled tributaries, the North River, North Branch, Cold River, Chickley River, Avery Brook, Clesson Brook, and South River. Highway damage was most important, although many of the losses would not recur in a similar flood. More than 110 bridges were washed out or wrecked. Most highways and railroads were closed for a week to ten days, and some highways were not reopened until the following summer. Approximately 470 houses and stores, and 20 industrial or utility plants were flooded. On the Deerfield River there was substantial control by the storage reservoirs of the New England Power Association until the crest reached Charlemont, Massachusetts, where high tributary inflow combined with floating debris to cause direct losses of $461,000 within that town. Stages and damage downstream in Shelburne and Buckland were increased by failure of the forebay at the New England Power No. 4 Dam. Damage to cultivated land was most important in the lower watershed, where the river valley is not so deep and narrow as in the upper basin. Several large tobacco farms in the lower valley were flooded and eroded. The tobacco had al-

ready been harvested and stored in drying sheds. Three drying sheds were washed out. On the North Branch of the Deerfield River above Harriman Reservoir, Wilmington and Dover, Vermont, together sustained damage of $196,000 to houses and stores in the village centers and to village streets and state highways. The Cold River entirely washed out approximately six miles of the Mohawk Trail, which follows up the river and passes into New York State. Approximately eight months were required before repairs could be completed on this main highway to enable it to be reopened to traffic. The Chickley River also caused extreme highway damage, washing out 18 bridges on local roads and contributing considerable debris to the main stream. The North River caused direct losses of approximately $1,000,000, principally to four large mills, 72 houses, and highways in Colrain, Massachusetts, and to highways, dwellings, and farms in Jacksonville and Halifax, Vermont. The South River, which lies wholly in the Town of Conway, Massachusetts, and flows through undeveloped country near the mouth of the Deerfield, wrecked 36 bridges on local roads.

13. CHICOPEE RIVER, MASSACHUSETTS. - Flood losses in the Chicopee River Watershed are discussed in Paragraph 65b of the Report.

14. WESTFIELD RIVER, MASSACHUSETTS. - The flood of September 1938 equalled the great flood of December 1878, and exceeded by a wide margin the flood of 1936, and also the flood of 1927 which had caused a loss of six lives. Direct losses of 1938 totaled $1,341,000. Damage to highways and railroads was most severe. Eighty-six bridges were damaged and many of the smaller structures were washed out. Railroad and highway traffic on the main routes between Boston and Albany was interrupted for one week, while less important routes remained closed for a longer period. Approximately 3,000 people evacuated their homes, although only 510 houses were damaged. Fourteen industrial plants and about 100 commercial units were damaged. On the upper Westfield River above Knightville, the town of Cummington

sustained damage amounting to $345,000 from extremely severe damage to highways, bridges, and to a few houses and stores. Below Knightville, industrial and residential losses became more important, in the towns of Russell and Westfield. Washouts occurred around the dams of the Strathmore Paper Company and Westfield River Paper Company in the town of Russell, where buildings, stock, and equipment were damaged, and a water main was severed. The large commercial and residential center of Westfield remained partially protected by a local levee built subsequent to the flood of 1878; although the lower area, which includes about 250 homes and a few stores, was flooded by washout of one section of the levee and back-up around the lower end. The West Branch caused considerable loss, although damage was not so severe as in 1927 when several important dams were washed out. There were large washouts of railroads and highways on the West Branch and water mains were severed at Chester and at Huntington. In Chester a group of 83 houses and stores and two mills were flooded. The business center of Huntington, which is located at the lower end of the West Branch, was flooded, and 46 houses and stores and one mill were damaged.

15. FARMINGTON RIVER, MASSACHUSETTS. - The flood of September 1938 was the maximum of record for it exceeded the flood of 1927 by 1 to 2 feet, and that of 1936 by 2 to 6 feet. Direct losses were $1,254,000 and the loss of two lives. A considerable portion of the watershed is devoted to agriculture. Approximately 2650 acres of tobacco and other rich farm lands were flooded and severely damaged by erosion and deposits of silt and gravel. Fourteen industrial plants and 55 commercial establishments were flooded and damaged. Approximately 620 families were forced to leave their homes and others were endangered by pollution of wells. Four highway bridges were destroyed and many sections of railroads, highways, and city streets were washed out. In Massachusetts at the headwaters of the Farmington

River, water flowed down through the main street in the village of New Boston, wrecking several buildings and damaging about 12 houses and a few commercial establishments. One man was drowned in this vicinity. At the village of Colebrook River in Connecticut, two bridges and four houses were washed out, the main street was eroded to a depth of six feet, and 20 houses were badly damaged. In the town of New Hartford, one residential group of 60 houses was flooded up to 10 feet deep and some were moved from their foundations, while two large industries also sustained severe damage. Direct losses in New Hartford totaled $152,000. Other industrial and commercial groups were flooded at Collinsville and Unionville. Along the lower river, rich tobacco and other farm lands were flooded and the grounds and cultivated fields of two private schools were damaged. Besides the physical damage to crops and lands, which make up one-third of the direct losses in this watershed, owners of land leased out to tobacco companies have had leases terminated, rents reduced, and have been forced to grow less valuable crops. There was no important damage on the East Branch of the Farmington River, which is controlled for water supply. The Still and Mad Rivers, which combine and join the Farmington River several miles below the Massachusetts-Connecticut State line, caused direct losses of $76,000 in the City of Winsted, Connecticut. Losses in Winsted are discussed in Paragraph 58 of the Report.

Direct Losses - Benefits

16. DEFINITION. - Direct losses are the physical damage to property and goods, measured by the present-day cost of repair or the replacement in kind, and the cost of cleanup and moving goods. Direct losses are divided into types, follows:

Residential. - Losses to homes and human habitations, other than farm buildings, including furnishings.

Commercial. - Damage to buildings, fixtures, stock, and merchandise in commercial establishments not engaged in manufacture.

Industrial. - Damage to all manufacturing developments, buildings, machinery, and stock.

Utility. - Losses to all public or private utilities, other than railroad.

Railroad. - Losses to track, structures, right-of-way, goods in transit or stored at terminals, supplies, and equipment.

Agricultural. - Losses to farm houses, land, and live stock, and physical damage to standing or harvested crops.

Public. - Losses to government-operated utilities, and to public and semi-public buildings and institutions.

17. COLLECTION OF BASIC DATA. - Losses of record form the basic data for the determination of average annual flood losses. The losses of the flood of September 1938 are described above. The flood of March 1936 caused damage totaling $34,500,000, while the flood of November 1927 resulted in damage of $15,526,000. These losses are summarized in Table I of the Report, and are described in further detail in the Report on Survey and Comprehensive Plan for Flood Control of the Connecticut River, published in House Document 455, Seventy-fifth Congress, second session. Losses from each of these floods, particularly those of 1936 and 1938, were based upon field investigation by competent appraisers who made preliminary estimates of flood damage immediately after the floods and compiled final estimates within the ensuing year, after thorough field investigation and appraisal of the major items of loss combined with information obtained from state and local agencies. The appraisals of flood damage were made with the object of determining:

a. Experienced direct losses, excluding important items of betterment.

b. Recurring losses, or anticipated future losses from floods similar to those of 1927, 1936, and 1938.

c. Relationship between stage of the river and recurring damage, from the stage of zero damage to the stage of the maximum predicted flood.

The field investigations also covered indirect and depreciation losses which are described in more detail later.

18. RECURRING LOSSES. - To provide the direct basis for estimating the flood losses which would be prevented by proposed measures, recurring losses were computed from data on the losses of 1936 and 1938, or of 1927 wherever they were the upper limit of known damage. Losses which are clearly non-recurring by reason of altered usage or abandonment were eliminated. The canvass of losses was made by damage zones. In each damage zone a definite reference gage with a good stage-discharge relation served as an index to stages throughout the reach. The damage zones are described in Table XIV and shown on Plate No. 12. Table XV summarizes the recurring direct losses by damage zones, based upon the flood of 1936 or on the floods of 1927 or 1938 wherever the 1936 flood was exceeded.

(Table XIV on following page)

TABLE XIV

DESCRIPTION OF DAMAGE ZONES

CONNECTICUT RIVER WATERSHED

ZONE NO.	RIVER	STATE	DESCRIPTION OF ZONE	INDEX STATION
C-1	CONNECTICUT	VT.-N.H.	FROM FIFTEEN MILE FALLS THROUGH TOWNS OF NEWBURY, VT., AND HAVERHILL, N. H.	U.S.G.S. GAGE AT SOUTH NEWBURY, VT.
C-2	CONNECTICUT	VT.-N.H.	FROM BELOW NEWBURY, VT. AND HAVERHILL, N. H. TO WILDER DAM.	WILDER DAM
C-3	CONNECTICUT	VT.-N.H.	FROM WILDER DAM THROUGH WINDSOR, VT. AND CORNISH, N.H.	U.S.G.S. GAGE AT WHITE RIVER JUNCTION, VT.
C-4	CONNECTICUT	VT.-N.H.	FROM BELOW WINDSOR, VT. AND CORNISH, N.H., TO BELLOWS FALLS DAM	BELLOWS FALLS DAM
C-5	CONNECTICUT	VT.-N.H.	FROM BELLOWS FALLS DAM TO VERNON DAM	VERNON DAM
C-6	CONNECTICUT	VT.-N.H. MASS.	FROM VERNON DAM TO MOUTH OF MILLERS RIVER	VERNON DAM TAILWATER (INCLUDES DISCHARGE FROM ASHUELOT RIVER)
C-7	CONNECTICUT	MASS.	FROM MOUTH OF MILLERS RIVER THROUGH HOLYOKE AND SOUTH HADLEY, MASS.	U.S.G.S. GAGE AT MONTAGUE CITY, MASS.
C-8	CONNECTICUT	MASS.	FROM BELOW HOLYOKE AND SOUTH HADLEY TO MASS.-CONN. STATE LINE.	MEMORIAL BRIDGE AT SPRINGFIELD, MASS.
C-9	CONNECTICUT	CONN.	FROM MASS.-CONN. STATE LINE TO MOUTH OF FARMINGTON RIVER.	U.S.G.S. GAGE AT THOMPSONVILLE, CONN.
C-10	CONNECTICUT	CONN.	BELOW MOUTH OF FARMINGTON RIVER.	MEMORIAL BRIDGE AT HARTFORD, CONN.
1-A	PASSUMPSIC	VT.	FROM EAST HAVEN DAM SITE TO MOUTH OF MILLERS RUN.	DARLING ESTATE DAM, EAST BURKE, VT.
1-B	PASSUMPSIC	VT.	FROM MOUTH OF MILLERS RUN TO TWIN STATE GAS AND ELECTRIC CO. DAM #1-1/2 AT ST. JOHNSBURY, VT.	LYNDONVILLE ELECTRIC CO. DAM - RIVER MILE 16.5
1-C	PASSUMPSIC	VT.	BELOW TWIN STATE GAS AND ELECTRIC CO. DAM #1-1/2.	U.S.G.S. GAGE AT PASSUMPSIC, VT.
1-D	PASSUMPSIC	VT.	MOOSE RIVER - BELOW VICTORY DAM SITE	U.S.G.S. AT ST. JOHNSBURY, VT.
2-A	STEVENS RIVER	VT.	BELOW HARVEY LAKE DAM SITE.	JUDKINS DAM NEAR BARNET CENTER, VT.
3-A	WELLS	VT.	BELOW GROTON POND DAM SITE.	HIGHWAY BRIDGE IN BOLTONVILLE, VT.
4-A	AMMONOOSUC	N. H.	FROM BETHLEHEM JUNCTION DAM SITE TO MOUTH OF GALE RIVER.	LITTLETON WATER & LIGHT CO. DAM-RIVER MILE 24.8
4-B	AMMONOOSUC	N.H.	BELOW MOUTH OF GALE RIVER	U.S.G.S. GAGE AT BATH, N.H.
4-X	AMMONOOSUC	N.H.	FROM UPPER BRETTON WOODS PROPERTY TO BETHLEHEM JUNCTION DAM SITE.	HIGHWAY BRIDGE AT TWIN MOUNTAIN, N. H.
4-Y	AMMONOOSUC	N.H.	GALE RIVER BELOW LITTLETON WATER SUPPLY DAM.	HIGHWAY BRIDGE AT FRANCONIA, N.H.
5-A	WAITS	VT.	BELOW SOUTH BRANCH DAM SITE.	CENTRAL VT. PUBLIC SERVICE CORP. DAM, BRADFORD, VT.
7-A	WHITE	VT.	FROM GAYSVILLE DAM SITE TO MOUTH OF THIRD BRANCH.	U.S.G.S. GAGE NEAR BETHEL, VT.
7-B	WHITE	VT.	FROM MOUTH OF THIRD BRANCH TO MOUTH OF SECOND BRANCH.	CENTRAL VT. PUBLIC SERVICE CORP. DAM - RIVER MILE 24.2
7-C	WHITE	VT.	FROM MOUTH OF SECOND BRANCH TO MOUTH OF FIRST BRANCH.	HIGHWAY BRIDGE AT ROYALTON, VT.
7-D	WHITE	VT.	BELOW MOUTH OF FIRST BRANCH.	U.S.G.S. GAGE AT WEST HARTFORD, VT.
7-E	WHITE	VT.	THIRD BRANCH BELOW MOUTH OF AYERS BROOK.	CENTRAL VT. RAILWAY BRIDGE, BETHEL, VT.
7-V	WHITE	VT.	THIRD BRANCH FROM MILE 17.0 ABOVE BRAINTREE, VT., TO MOUTH OF AYERS BROOK.	HIGHWAY BRIDGE IN RANDOLPH, VT.
7-W	WHITE	VT.	SECOND BRANCH BELOW A POINT JUST ABOVE NO. RANDOLPH, VT.	HYDE MILL DAM IN EAST BETHEL, VT.
7-X	WHITE	VT.	FIRST BRANCH BELOW HIGHWAY BRIDGE AT RIVER MILE 14.8.	ROYALTON CO. DAM - RIVER MILE 0.75.
7-Y	WHITE	VT.	FROM DAM AT MILE 53.7 ABOVE GRANVILLE, VT. TO GAYSVILLE DAM SITE.	HIGHWAY BRIDGE BELOW ROCHESTER, VT. - RIVER MILE 43.8.

TABLE XIV (CONTINUED)

ZONE NO.	RIVER	STATE	DESCRIPTION OF ZONE	INDEX STATION
8-A	MASCOMA	N.H.	FROM WEST CANAAN DAM SITE TO MASCOMA LAKE OUTLET.	AMERICAN WOOLEN CO. DAM AT ENFIELD, N. H.
8-B	MASCOMA	N.H.	BELOW MASCOMA LAKE OUTLET.	GRAFTON COUNTY ELECTRIC CO. DAM, PLANT NO. 1.
9-W	OTTAUQUECHEE	VT.	BELOW HIGHWAY BRIDGE (RIVER MILE 24.0) AT BRIDGEWATER CORNERS, VT.	U.S.G.S. GAGE NEAR NO. HARTLAND, VT.
10-A	SUGAR	N.H.	FROM MOUTH OF CROYDON BRANCH TO CLAREMONT DAM SITE.	COVERED RAILWAY BRIDGE #178 - RIVER MILE 11.0.
10-B	SUGAR	N.H.	BELOW CLAREMONT DAM SITE.	U.S.G.S. GAGE AT WEST CLAREMONT, N. H.
10-C	SUGAR	N.H.	CROYDON BRANCH BELOW STOCKER POND DAM SITE.	HIGHWAY BRIDGE AT GRANTHAM, N. H.
10-W	SUGAR	N.H.	FROM SUNAPEE LAKE TO MOUTH OF CROYDON BRANCH.	GORDON WOOLEN CO. DAM AT NEWPORT, N. H.
11-A	BLACK	VT.	FROM LUDLOW DAM SITE TO PERKINSVILLE DAM SITE.	VT. HYDROELECTRIC CO. DAM NEAR CAVENDISH, VT.
11-B	BLACK	VT.	FROM PERKINSVILLE DAM SITE TO NORTH SPRINGFIELD DAM SITE.	VT. HYDROELECTRIC CO. DAM AT PERKINSVILLE, VT.
11-C	BLACK	VT.	BELOW NORTH SPRINGFIELD DAM SITE.	U.S.G.S. GAGE AT NORTH SPRINGFIELD, VT.
12-A	SAXTONS	VT.	BELOW CAMBRIDGEPORT DAM SITE.	BLAKE AND HIGGINS DAM AT GAGEVILLE, VT.
13-A	WEST	VT.	BELOW NEWFANE DAM SITE.	TWIN STATE GAS & ELECTRIC CO. DAM - RIVER MILE 7.4.
13-Y	WEST	VT.	FROM ABOVE WESTON, VT., MILE 46.0, TO MOUTH OF BALL MOUNTAIN BROOK.	NEW DAM AT SOUTH LONDONDERRY, VT.
13-Z	WEST	VT.	FROM MOUTH OF BALL MOUNTAIN BROOK TO NEWFANE DAM SITE.	U.S.G.S. GAGE AT NEWFANE, VT.
14-A	ASHUELOT	N.H.	FROM SURRY MOUNTAIN DAM SITE TO FAULKNER & COLONY CO. DAM.	SECTION ABOVE KEENE, N. H., AT RIVER MILE 30.9.
14-B	ASHUELOT	N.H.	FROM FAULKNER AND COLONY CO. DAM TO MOUTH OF OTTER BROOK.	M.A. DICKINSON DAM AT WEST SWANZEY, N. H.
14-C	ASHUELOT	N.H.	FROM MOUTH OF OTTER BROOK THROUGH VILLAGE OF ASHUELOT, N. H.	HIGHWAY BRIDGE ABOVE WESTPORT, N. H. - MILE 16.5.
14-F	ASHUELOT	N.H.	BELOW VILLAGE OF ASHUELOT, N. H.	U.S.G.S. GAGE AT HINSDALE, N.H.
14-M	ASHUELOT	N.H.	OTTER BROOK BELOW OTTER BROOK DAM SITE.	U.S.G.S. GAGE AT KEENE, N.H.
14-X	ASHUELOT	N.H.	MINNEWAWA BROOK BELOW PUBLIC SERVICE CO. DAM - MARLBORO, N.H.	MONADNOCK BLANKET CO. DAM AT MARLBORO, N. H.
15-C	MILLERS	MASS.	FROM LOWER NAUKEAG DAM SITE TO BIRCH HILL DAM SITE.	MASON & PARKER DAM AT WINCHENDON, MASS. (UPPER DAM)
15-E	MILLERS	MASS.	FROM BIRCH HILL DAM SITE TO STARRETT CO. DAM, ATHOL, MASS.	ATHOL MFG. CO. DAM AT ATHOL, MASS.
15-G'	MILLERS	MASS.	FROM STARRETT CO. DAM TO MOUTH OF MOSS BROOK.	CHASE TURBINE CO. DAM AT ORANGE, MASS.
15-H'	MILLERS	MASS.	BELOW MOUTH OF MOSS BROOK.	U.S.G.S. GAGE AT ERVING, MASS.
15-D	MILLERS	MASS.	PRIEST BROOK BELOW PRIEST POND DAM SITE.	U.S.G.S. GAGE NEAR WINCHENDON, MASS.
15-F	MILLERS	MASS.	TULLY RIVER BELOW TULLY DAM SITE.	U.S.G.S. GAGE ON EAST BRANCH OF TULLY RIVER NEAR ATHOL, MASS.
15-X	MILLERS	MASS.	OTTER RIVER BELOW HAMLET DAM SITE.	OTTER RIVER BOARD CO. DAM AT OTTER RIVER, MASS.
16-U	DEERFIELD	MASS.	FROM VERMONT-MASSACHUSETTS STATE LINE TO MOUTH OF NORTH RIVER.	U.S.G.S. GAGE AT CHARLEMONT, MASS.
16-V	DEERFIELD	MASS.	BELOW MOUTH OF NORTH RIVER.	WESTERN MASS. ELECTRIC CO. DAM AT SHELBURNE FALLS, MASS.
16-W	DEERFIELD	VT.-MASS.	GREEN RIVER FROM 1 MILE ABOVE VILLAGE OF GREEN RIVER, VT., TO MOUTH.	GREENFIELD PUMPING STATION DAM - RIVER MILE 7.2.
16-X	DEERFIELD	VT.-MASS.	NORTH RIVER BELOW A POINT 1/2 MILE ABOVE JACKSONVILLE, VT.	GRISWOLD DAM AT GRISWOLDVILLE, MASS.

TABLE XIV (CONTINUED)

ZONE NO.	RIVER	STATE	DESCRIPTION OF ZONE	INDEX STATION
16-Y	DEERFIELD	VT.	WEST BRANCH BELOW A POINT 1 MILE ABOVE READSBORO FALLS, VT.	J. F. CARRIER DAM AT READSBORO FALLS, VT.
16-Z	DEERFIELD	VT.	NORTH BRANCH BELOW A POINT 1 MILE ABOVE WEST DOVER, VT.	SECTION ABOVE WILMINGTON, VT. AT RIVER MILE 2.4.
22-A	CHICOPEE	MASS.	WARE RIVER FROM BARRE FALLS DAM SITE TO MET. DIST. WATER SUPPLY COMM. DAM BELOW COLD BROOK, MASS.	U.S.G.S. GAGE AT COLD BROOK, MASS.
22-B	CHICOPEE	MASS.	WARE RIVER BELOW MET. DIST. WATER SUPPLY COMMISSION DAM.	U.S.G.S. GAGE AT GIBBS CROSSING, MASS.
17-A	CHICOPEE	MASS.	SWIFT RIVER FROM WINSOR DAM TO MOUTH OF WARE RIVER.	U.S.G.S.GAGE AT WEST WARE, MASS.
21-A	CHICOPEE	MASS.	QUABOAG RIVER FROM WIRE VILLAGE, MASS. TO WICKABOAG POND.	SECTION AT W. BROOKFIELD, MASS., AT RIVER MILE 17.8.
21-B	CHICOPEE	MASS.	QUABOAG RIVER FROM WICKABOAG POND TO CENTRAL VERMONT RAILWAY BRIDGE 1-1/2 MILES ABOVE MOUTH.	U.S.G.S. GAGE AT WEST BRIMFIELD, MASS.
17-B	CHICOPEE	MASS.	FROM MOUTH OF WARE RIVER TO AMES SWORD CO. DAM.	DWIGHT MFG. CO. DAM AT CHICOPEE, MASS.
18-A	WESTFIELD	MASS.	FROM KNIGHTVILLE DAM SITE TO MOUTH OF WEST BRANCH.	U.S.G.S. GAGE AT KNIGHTVILLE, MASS.
18-B	WESTFIELD	MASS.	FROM MOUTH OF WEST BRANCH TO MOUTH OF WESTFIELD LITTLE RIVER.	SECTION AT WESTFIELD, MASS., AT RIVER MILE 11.0.
18-C	WESTFIELD	MASS.	BELOW MOUTH OF WESTFIELD LITTLE RIVER.	U.S.G.S. GAGE AT WESTFIELD, MASS.
18-V	WESTFIELD	MASS.	FROM ABOVE WEST CUMMINGTON, MASS., TO KNIGHTVILLE DAM SITE.	U.S.G.S. GAGE AT KNIGHTVILLE, MASS.
18-W	WESTFIELD	MASS.	WEST BRANCH BELOW AND INCLUDING BECKET, MASS.	U.S.G.S. GAGE AT HUNTINGTON, MASS.
18-X	WESTFIELD	MASS.	MIDDLE BRANCH BELOW HIGHWAY BRIDGE AT RIVER MILE 13.0.	U.S.G.S. GAGE AT GOSS HEIGHTS, MASS.
19-U	FARMINGTON	MASS.	WEST BRANCH FROM 1/2 MILE ABOVE NEW BOSTON, MASS. TO MASSACHUSETTS-CONNECTICUT STATE LINE.	U.S.G.S. GAGE AT NEW BOSTON, MASS.
19-V	FARMINGTON	CONN.	WEST BRANCH FROM MASSACHUSETTS-CONNECTICUT STATE LINE TO MOUTH OF EAST BRANCH.	U.S.G.S. GAGE AT RIVERTON, CONN.
19-W	FARMINGTON	CONN.	FROM MOUTH OF EAST BRANCH TO MOUTH OF PEQUABUCK RIVER.	COLLINS CO. DAM (UPPER) AT COLLINSVILLE, CONN.
19-X	FARMINGTON	CONN.	BELOW MOUTH OF PEQUABUCK RIVER.	U.S.G.S. GAGE AT TARIFFVILLE, CONN.
19-Y	FARMINGTON	CONN.	STILL RIVER BELOW A POINT 4 MILES BELOW TORRINGTON, CONN. MAD RIVER BELOW BRIDGE 600 FEET ABOVE MOUTH OF INDIAN MEADOW BROOK.	CONNECTICUT LIGHT & POWER CO. DAM AT WINSTED, CONN.

TABLE XV

DIRECT FLOOD LOSSES--CONNECTICUT RIVER WATERSHED
SUMMARY OF RECURRING LOSSES BELOW RESERVOIR SITES CONSIDERED
BASED UPON 1927, 1936,& 1938 FLOODS.

DIRECT RECURRING FLOOD LOSS

RIVER	ZONE	YEAR OF MAX. FLOOD	URBAN*	RURAL	INDUSTRIAL**	HIGHWAY	RAILROAD	TOTAL
CONNECTICUT	VT., N.H. 1	'36	$31,700	$23,400	$14,200	$6,700	$26,600	$102,600
"	VT., N.H. 2	"	18,700	27,600	6,100	146,400	38,000	236,800
"	VT., N.H. 3	"	37,500	21,100	158,700	11,500	34,400	263,200
"	VT., N.H. 4	"	5,300	24,100	12,000	282,300	48,600	372,300
"	VT., N.H. 5	"	17,200	79,900	179,500	212,800	296,700	786,100
"	MASS.,VT., N.H. 6	"	2,200	214,600	4,900	140,100	191,400	553,200
"	MASS. 7	"	1,097,300	484,900	1,652,500	623,600	117,800	3,976,100
"	MASS. 8	"	3,527,200	61,700	3,545,500	538,600	171,000	7,844,100
"	CONN. 9	"	47,500	36,200	199,500	38,300	7,900	329,400
"	CONN. 10	"	3,372,400	313,800	5,854,300	770,500	108,800	10,419,800
TOTAL FOR CONN. RIVER			8,157,000	1,287,300	11,627,200	2,770,800	1,041,300	24,883,600
TRIBUTARY STREAMS								
PASSUMPSIC	VT. 1A	'27	8,400	18,000	25,000	57,000	60,000	168,400
"	VT. 1B	"	110,800	19,000	24,500	145,000	80,000	379,300
"	VT. 1C	"	51,300	5,100	85,700	123,000	90,000	355,100
" (MOOSE)	VT. 1D	"	3,100	2,500	5,000	12,000	16,000	38,600
STEVENS	VT. 2A	"	1,500	-	700	15,000	-	17,200
WELLS	VT. 3A	"	66,300	4,200	30,000	45,300	87,300	233,100
AMMONOOSUC	N.H. 4A	"	3,400	9,000	30,600	22,000	3,000	68,000
"	N.H. 4B	"	18,000	25,400	20,000	31,100	14,900	109,400
"	N.H. 4X	"	30,800	-	-	15,000	6,100	51,800
"	N.H. 4Y	"	1,400	1,400	2,800	8,500	-	14,100
WAITS	VT. 5A	"	-	800	1,000	2,000	-	3,800
WHITE	VT. 7A	"	5,100	21,800	-	55,200	1,000	83,100
"	VT. 7B	"	2,700	-	-	5,000	7,000	14,700
"	VT. 7C	"	4,000	-	-	30,000	-	34,000
"	VT. 7D	"	25,700	20,500	-	33,000	-	79,200
"	VT. 7E	"	10,000	-	137,600	-	-	147,600
"	VT. 7V	"	-	700	3,000	-	1,700	5,400
"	VT. 7W	"	-	-	-	-	-	-
"	VT. 7X	"	2,200	-	-	7,200	-	9,400
"	VT. 7Y	"	8,200	18,800	-	33,000	-	60,000
MASCOMA	N.H. 8A	'36	300	-	200	400	1,300	2,200
"	N.H. 8B	"	36,400	1,100	2,100	100	600	40,200
OTTAUQUECHEE	VT. 9W	'38	1,500	1,700	83,000	2,000	-	88,200
SUGAR	N.H.10A	'36	-	300	2,300	200	100	2,900
"	N.H.10B	"	4,600	500	3,300	100	-	8,500
"	N.H.10C	"	100	-	-	1,100	-	1,200
"	N.H.10W	"	700	1,700	500	1,400	1,400	5,700
BLACK	VT. 11A	'38	86,900	5,500	14,200	10,000	-	116,600
"	VT. 11B	"	-	4,200	-	-	-	4,200
"	VT. 11C	"	16,100	2,600	18,300	-	-	37,000
SAXTONS	VT. 12A	'27	-	-	-	8,300	-	8,300
WEST	VT. 13A	'38	300	2,900	1,200	15,000	-	19,400
"	VT. 13Y	"	37,500	-	-	45,000	-	82,500
"	VT. 13Z	"	800	15,500	1,000	15,000	-	32,300
ASHUELOT	N.H. 14A	"	2,400	100	-	3,300	-	5,800
"	N.H. 14B	"	98,400	13,000	97,000	3,700	21,000	233,100
"	N.H. 14C	"	54,800	31,900	64,400	3,500	6,500	161,100
"	N.H. 14F	"	700	-	18,700	9,500	1,200	30,100
"	N.H. 14M	"	500	1,100	500	700	-	2,800
"	N.H. 14X	"	6,000	1,700	11,900	14,500	-	34,100
MILLERS	MASS. 15C	"	18,600	9,000	59,000	36,300	12,600	135,500
"	MASS. 15E	"	2,100	-	67,300	11,000	24,600	105,000
"	MASS. 15G'	"	467,300	24,700	442,700	41,800	70,100	1,046,600
"	MASS. 15H'	"	1,500	800	113,100	41,600	527,400	684,400
"	MASS. 15D	"	100	600	-	3,900	-	4,600
"	MASS. 15F	"	-	-	-	3,000	-	3,000
"	MASS. 15X	"	36,000	4,500	201,700	24,500	165,200	431,900

TABLE XV (CONTINUED)

RIVER	ZONE	YEAR OF MAX. FLOOD	URBAN*	RURAL	INDUSTRIAL**	HIGHWAY	RAILROAD	TOTAL
DEERFIELD	MASS. 16U	'38	21,300	14,400	133,200	23,100	88,500	280,500
"	MASS. 16V	"	52,800	53,400	50,100	7,400	19,600	183,300
"	MASS.,VT. 16W	"	2,700	100	2,700	20,000	-	25,500
"	MASS.,VT. 16X	"	54,100	70,900	31,800	70,900	-	227,700
"	VT. 16Y	"	-	-	7,300	3,600	-	10,900
"	VT. 16Z	"	66,000	-	-	60,500	-	126,500
CHICOPEE	MASS. 22A	"	-	-	1,300	-	1,000	2,300
"	MASS. 22B	"	341,300	69,900	785,200	59,000	38,500	1,293,900
"	MASS. 17A	"	-	3,000	16,800	-	-	19,800
"	MASS. 21A	"	19,900	14,300	4,100	7,000	15,500	60,800
"	MASS. 21B	"	38,400	11,400	101,200	31,100	15,200	197,300
"	MASS. 17B	"	179,100	18,800	342,200	95,400	3,000	643,500
WESTFIELD	MASS. 18A	"	1,700	400	1,600	1,800	500	6,000
"	MASS. 18B	"	117,300	8,700	225,600	33,100	12,000	396,700
"	MASS. 18C	"	10,600	10,800	1,200	21,500	1,100	45,200
"	MASS. 18V	"	6,100	1,700	3,000	71,000	-	81,800
"	MASS. 18W	"	26,600	1,600	35,100	9,800	9,500	82,600
"	MASS. 18X	"	600	400	-	18,400	-	19,400
FARMINGTON	MASS. 19U	"	10,000	-	700	20,400	-	31,100
"	CONN. 19V	"	50,600	14,000	107,200	53,300	200	225,300
"	CONN. 19W	"	70,000	17,600	88,600	98,500	23,000	297,700
"	CONN. 19X	"	31,900	323,200	13,800	600	7,900	377,400
"	CONN. 19Y	"	68,400	1,400	6,400	25,500	3,000	104,700
TOTAL FOR TRIBUTARY STREAMS			2,395,900	906,600	3,527,400	1,667,100	1,442,400	9,939,400
GRAND TOTAL			10,552,900	2,193,900	15,154,600	4,437,900	2,483,700	34,823,000

* INCLUDES RESIDENTIAL, COMMERCIAL, AND PUBLIC.

** INCLUDES UTILITY.

19. DISCHARGE-LOSS RELATIONSHIP. - The relation between direct loss and stage, referenced to the flood crest of record, was determined for each large industry or important property, and for separate residential, commercial, and other areas. The relation was established for a range in stage extending from the beginning of damage to the level of the flood having a 0.1 percent chance of occurrence, using the recurring preventable losses of November 1927, March 1936, and September 1938 as a control. Individual losses were related to stage at the index station for each reach and summated for one-foot increments of stage. Curves of total direct recurring losses versus discharge were prepared for each damage zone by means of the discharge rating curves at the index stations. Stage-loss curves for various damage centers were also prepared wherever they were required for local protection studies.

20. AVERAGE ANNUAL DIRECT LOSSES. - The damage-frequency relationship was obtained for each damage zone from the relationship of damage to discharge derived above, and the discharge-frequency relation from record, described in Paragraph 4a, Section 1 of the Appendix. The natural direct loss-frequency relation was plotted between 100 and 1.0 percent chance. Between 1.0 percent and 0 percent chance the curve was distorted to the value of the direct loss from one flood having a 0.1 percent chance of occurrence. The average annual direct loss was then taken as the mean ordinate of the entire 100 percent chance period. Annual losses are summarized in Table XVI.

(Table XVI on following page)

TABLE XVI

NATURAL LOSSES AND REDUCTION OF LOSSES BY RESERVOIRS IN THE REVISED COMPREHENSIVE PLAN

			RECURRING DIRECT FLOOD LOSSES						AVERAGE ANNUAL RECURRING LOSSES							
			1927 FLOOD		1936 FLOOD		1938 FLOOD		NATURAL				REDUCTION BY RESERVOIRS			
RIVER	Zone No.	INDEX STATION	Natural	Reduction by Reservoirs	Natural	Reduction by Reservoirs	Natural	Reduction by Reservoirs	Direct	Indirect	Depreciation of Property Value	Total	Direct	Indirect	Restoration of Property Value	Total
Connecticut	C-1	U.S.G.S. Gage at South Newbury, Vt.	$ 36,200	$ 36,200	$ 102,600	$ 102,600	$ 9,300	$ 9,300	$ 34,600	$ 22,600	$ 200	$ 57,400	$ 30,600	$ 19,900	$ 100	$ 50,600
	C-2	Wilder Dam	38,800	38,800	236,800	236,800	0	0	31,000	27,000	200	58,200	26,600	23,100	0	49,700
	C-3	U.S.G.S. Gage at White River Junction, Vt.	681,800	681,800	263,200	263,200	3,200	3,200	42,400	41,500	4,400	88,300	40,000	39,100	1,400	80,500
	C-4	Bellows Falls Dam	534,400	534,400	372,300	372,300	19,800	19,800	34,500	30,600	200	65,300	32,700	29,200	200	62,100
	C-5	Vernon Dam	163,500	163,500	766,100	774,100	44,600	44,600	42,100	39,100	6,800	88,000	37,800	35,300	5,000	78,100
	C-6	Vernon Dam Tailwater (including discharge from Ashuelot River)	109,900	109,900	653,200	553,200	0	0	24,100	15,900	100	40,100	23,900	15,800	100	39,800
	C-7	U.S.G.S. Gage at Montague City, Mass.	600,000	600,000	3,976,100	3,966,100	1,500,000	1,440,000	220,000	187,000	227,900	634,900	214,300	182,100	205,000	601,400
	C-8	Memorial Bridge at Springfield, Mass.	370,000	350,000	7,844,100	7,664,100	4,022,800	3,972,600	278,100	239,200	1,150,000	1,667,300	246,200	211,200	906,000	1,363,400
	C-9	U.S.G.S. Gage at Thompsonville, Conn.	25,200	25,200	329,400	319,400	155,800	152,800	15,900	16,200	16,100	48,200	16,200	14,700	10,200	40,100
	C-10	Memorial Bridge at Hartford, Conn.	994,200	914,200	10,419,800	9,419,800	7,765,000	7,175,000	299,800	277,700	1,335,900	1,913,400	266,900	247,400	1,240,000	1,754,300
		Connecticut River Totals	3,359,000	3,254,000	24,883,600	23,671,600	13,510,200	12,817,200	1,022,500	895,800	2,740,800	4,659,100	934,200	817,800	2,368,000	4,120,000
Passumpsic	1-a	Darling Estate Dam, East Burke, Vt.	168,400	122,000	13,600	9,800	2,900	1,900	7,800	7,200	0	15,000	5,200	4,800	0	10,000
	1-b	Lyndonville Electric Co. Dam - River Mile 16.5	379,300	169,300	1,000	1,000	3,400	2,400	10,600	9,500	4,500	24,600	5,700	5,200	500	11,400
	1-c	U.S.G.S. Gage at Passumpsic, Vt.	356,100	280,100	40,500	38,500	1,200	1,200	13,100	13,100	2,400	28,600	5,800	5,800	100	11,700
	1-d	U.S.G.S. Gage on Moose River at St. Johnsbury, Vt.	38,600	27,600	6,800	6,800	200	200	4,400	4,000	0	8,400	3,500	3,100	0	6,600
Stevens	2-a	Judkins Dam near Barnet Center, Vt.	17,200	0	3,000	0	0	0	4,200	4,100	0	8,300	0	0	0	0
Wells	3-a	Highway Bridge in Boltonville, Vt.	233,100	0	10,200	0	0	0	16,800	14,800	1,200	31,800	0	0	0	0
Ammonoosuc	4-a	Littleton Water & Light Co. Dam - River Mile 24.8	68,000	0	11,300	0	17,000	0	15,000	12,400	0	27,400	0	0	0	0
	4-b	U.S.G.S. Gage at Bath, N. H.	109,400	100,400	29,900	28,900	24,000	23,500	10,600	8,800	500	19,900	9,000	7,500	100	16,600
	4-x	Highway Bridge at Twin Mountain, N. H.	51,900	0	4,800	0	0	0	21,600	2,400	0	24,000	0	0	0	0
	4-y	Highway Bridge on Gale River at Franconia, N. H.	14,100	0	4,900	0	4,900	0	4,600	3,700	0	8,300	0	0	0	0
Waits	5-a	Central Vt. Public Service Corp. Dam, Bradford, Vt.	3,800	1,000	600	600	100	100	500	500	100	1,100	300	200	0	500
White	7-a	U.S.G.S. Gage near Bethel, Vt.	83,100	71,900	3,500	3,500	50,000	50,000	5,900	4,500	100	10,500	5,500	4,200	100	9,800
	7-b	Central Vt. Public Service Corp. Dam - River Mile 24.2	14,700	11,900	1,000	1,000	2,800	2,800	700	700	0	1,400	600	500	0	1,100
	7-c	Highway Bridge at Royalton, Vt.	34,000	26,000	2,000	2,000	2,000	2,000	1,600	1,500	100	3,200	1,400	1,300	0	2,700
	7-d	U.S.G.S. Gage at West Hartford, Vt.	79,200	43,000	2,500	2,500	3,000	3,000	2,900	2,600	400	5,900	2,400	2,100	0	4,500
	7-e	Central Vt. Railway Bridge on Third Branch at Bethel, Vt.	147,600	65,600	0	0	30,000	13,800	14,800	17,000	0	31,800	5,700	6,500	0	12,200
	7-v	Highway Bridge on Third Branch at Randolph, Vt.	5,400	0	700	0	4,700	0	1,000	900	200	2,100	0	0	0	0
	7-w	Hyde Mill Dam on Second Branch at E. Bethel, Vt.	0	0	0	0	0	0	100	0	0	100	0	0	0	0
	7-x	Royalton Co. Dam on First Branch - River Mile 14.8	9,400	0	0	0	2,400	0	2,100	1,500	100	3,700	0	0	0	0
	7-y	Highway Bridge below Rochester, Vt.	60,000	0	0	0	39,000	0	13,600	9,100	0	22,700	0	0	0	0
Mascoma	8-a	American Woolen Co. Dam at Enfield, N. H.	2,000	2,000	2,200	2,200	1,800	1,800	1,700	1,700	200	3,600	1,400	1,400	100	2,900
	8-b	Grafton County Electric Co. Dam Plant #1	23,000	17,000	40,200	22,200	23,000	17,000	18,800	11,400	1,500	31,700	11,700	7,200	300	19,200
Ottauquechee	9-w	U.S.G.S. Gage near No. Hartland, Vt.	88,200	0	22,200	0	88,200	0	18,800	21,800	1,000	41,600	0	0	0	0
Sugar	10-a	Covered Railway Bridge #178, River Mile 11.0	0	0	2,900	0	2,300	0	1,400	1,400	0	2,800	0	0	0	0
	10-b	U.S.G.S. Gage at West Claremont, N. H.	1,800	1,800	6,500	6,500	7,000	7,000	4,700	4,100	0	8,800	[illegible]	3,900	0	6,400
	10-c	Highway Bridge on Croydon Branch at Grantham, N. H.	500	0	1,200	0	1,000	0	600	500	0	1,100	0	0	0	0
	10-w	Gordon Woolen Co. Dam at Newport, N. H.	0	0	5,700	0	4,000	0	9,300	7,700	100	17,100	0	0	0	0
Black	11-a	Vt. Hydroelectric Co. Dam near Cavendish, Vt.	196,000	192,000	60,000	60,000	116,600	116,600	34,800	26,000	3,300	64,100	31,800	[illegible]	1,200	[illegible]
	11-b	Vt. Hydroelectric Co. Dam at Perkinsville, Vt.	12,000	7,600	3,600	2,400	4,200	2,600	1,700	1,100	200	3,000	1,000	700	100	1,800
	11-c	U.S.G.S. Gage at No. Springfield, Vt.	189,000	169,000	25,000	25,000	37,000	37,000	15,900	15,300	4,400	35,600	[illegible]	[illegible]	2,000	[illegible]
Saxtons	12-a	Blake and Higgins Dam at Gageville, Vt.	8,300	8,300	3,300	3,300	4,500	4,500	1,300	1,400	0	2,700	1,200	1,100	0	2,300
West	13-a	Twin State Gas and Electric Co. Dam - River Mile 7.4	12,000	12,000	6,600	6,600	19,400	19,400	900	800	0	1,700	900	800	0	1,700
	13-y	New Dam at South Londonderry, Vt.	40,000	0	15,000	0	82,500	0	10,600	8,200	800	19,600	0	0	0	0
	13-z	U.S.G.S. Gage at Newfane, Vt.	17,500	0	8,500	0	32,300	0	1,900	1,200	0	3,100	0	0	0	0
Ashuelot	14-a	Section at River Mile 30.9 - 2.8 Mi. above Keene, N. H.	0	0	1,500	1,500	5,600	5,700	300	200	1,100	1,600	300	200	900	1,400
	14-b	M.A. Dickinson Dam at West Swanzey, N. H.	10,000	10,000	68,000	60,000	233,100	222,100	22,900	19,000	24,500	66,400	15,700	13,100	9,000	37,800
	14-c	Highway Bridge above Westport, N. H. - Mile 16.5	40,000	40,000	106,000	103,000	161,100	153,100	37,000	28,800	0	65,800	26,200	20,500	0	46,700
	14-f	U.S.G.S. Gage at Hinsdale, N. H.	20,000	17,000	40,000	30,000	30,100	22,100	14,300	16,100	0	30,400	6,200	6,900	0	13,100
	14-m	U.S.G.S. Gage on Otter Brook near Keene, N. H.	900	900	1,000	1,000	2,800	2,800	400	300	300	1,000	400	300	200	900
	14-x	Monadnock Blanket Co. Dam on Minnewawa Brook at Marlboro, N.H.	-	0	7,600	0	34,100	0	4,000	3,600	900	8,500	0	0	0	0
Millers	15-c	Mason and Parker Dam at Winchendon, Mass. (Upper Dam)	0	0	49,500	31,500	135,500	52,500	8,900	8,600	5,400	22,900	5,400	5,200	500	11,100
	15-e	Athol Mfg. Co. Dam at Athol, Mass.	0	0	22,000	22,000	105,000	64,000	6,400	7,200	5,500	19,100	5,700	6,400	3,800	15,900
	15-g'	Chase Turbine Co. Dam at Orange, Mass.	0	0	395,000	379,000	1,046,600	811,600	31,500	26,200	25,000	82,700	26,100	21,700	16,800	64,600
	15-h'	U.S.G.S. Gage at Erving, Mass.	52,000	52,000	382,000	210,000	684,400	296,400	34,400	35,500	6,800	76,700	25,300	26,000	2,700	54,000
	15-d	U.S.G.S. Gage on Priest Brook near Winchendon, Mass.	1,600	0	3,000	0	4,600	0	400	400	0	800	0	0	0	0
	15-f	U.S.G.S. Gage on East Branch of Tully River near Athol, Mass.	0	0	1,800	1,800	3,000	3,000	100	100	0	200	100	100	0	200
	15-x	Otter River Board Co. Dam on Otter River at Otter River, Mass.	0	0	25,000	0	431,900	0	6,300	6,600	2,600	15,500	0	0	0	0
Deerfield	16-u	U.S.G.S. Gage at Charlemont, Mass.	16,000	0	22,000	0	280,500	0	14,800	13,300	0	28,100	0	0	0	0
	16-v	Western Mass. Electric Co. Dam at Shelburne Falls, Mass.	7,000	2,000	52,000	17,000	183,300	30,300	17,400	11,800	0	29,200	2,200	1,500	0	3,700
	16-w	Greenfield Pumping Station Dam on Green River - River Mile 7.2	1,400	0	2,800	0	25,500	0	1,100	1,100	0	2,200	0	0	0	0
	16-x	Griswold Dam on North River at Griswoldville, Mass.	0	0	10,000	7,300	227,700	96,200	36,800	24,600	900	62,300	5,600	[illegible]	0	9,300
	16-y	J.F. Carrier Dam on West Branch at Readsboro Falls, Vt.	2,700	0	1,200	0	13,900	0	1,400	1,600	0	3,000	0	0	0	0
	16-z	River Section on North Branch - River Mile 2.4	21,000	0	12,500	0	126,500	0	2,200	1,600	400	4,200	0	0	0	0
Chicopee	22-a	U.S.G.S. Gage on Ware River at Cold Brook, Mass.	-	-	0	0	2,300	2,000	100	200	0	300	100	100	0	200
	22-b	U.S.G.S. Gage on Ware River at Gibbs Crossing, Mass.	-	-	212,000	122,000	1,293,900	517,900	64,700	61,200	29,000	154,900	17,700	16,800	500	35,000
	17-a	U.S.G.S. Gage on Swift River at West Ware, Mass.	1,000	0&	65,000	0*	19,800	0**	100	100	0	200	0	0	0	0
	21-a	Section on Quaboag River at West Brookfield, Mass.	-	-	6,500	5,600	60,800	54,800	5,300	3,500	300	9,100	3,600	2,400	100	6,100
	21-b	U.S.G.S. Gage on Quaboag River at West Brimfield, Mass.	-	-	44,000	29,000	197,300	154,300	16,300	15,700	0	32,000	9,300	8,900	0	18,200
	17-b	Dwight Mfg. Co. Dam at Chicopee, Mass.	0	0	68,000	16,000#	643,500	162,000##	24,600	23,200	32,000	79,800	6,100	5,700	3,000	14,800
Westfield	18-a	U.S.G.S. Gage at Knightville, Mass.	0	0	600	600	6,000	5,900	2,000	1,600	0	3,600	1,900	1,600	0	3,500
	18-b	River Section - Mile 11.0	109,300	77,300	240,000	162,000	396,700	191,700	39,600	38,000	11,500	89,100	20,900	20,100	4,500	45,500
	18-c	U.S.G.S. Gage at Westfield, Mass.	4,000	4,000	13,000	11,000	45,200	35,200	7,300	5,500	0	12,800	2,200	1,600	0	3,800
	18-v	U.S.G.S. Gage at Knightville, Mass.	0	0	7,000	0	81,800	0	4,200	4,000	0	8,200	0	0	0	0
	18-w	U.S.G.S. Gage on the West Branch at Huntington, Mass.	11,500	0	10,000	0	82,600	0	5,800	5,200	300	11,300	0	0	0	0
	18-x	U.S.G.S. Gage on the Middle Branch at Goss Heights, Mass.	0	0	400	0	13,400	0	300	300	0	600	0	0	0	0
Farmington	19-u	U.S.G.S. Gage at New Boston, Mass.	500	0	1,300	0	31,100	0	1,700	1,400	0	3,100	0	0	0	0
	19-v	U.S.G.S. Gage at Riverton, Conn.	118,200	0	43,800	0	225,300	0	27,600	25,500	0	53,100	0	0	0	0
	19-w	Collins Co. Dam (Upper) at Collinsville, Conn.	-	0	81,100	0	297,700	0	22,900	20,200	2,500	45,600	0	0	0	0
	19-x	U.S.G.S. Gage at Tariffville, Conn.	-	0	88,000	0	377,400	0	12,900	3,600	6,200	22,700	0	0	0	0
	19-y	Connecticut Light & Power Co. Dam at Winsted, Conn.	-	0	37,500	0	104,700	0	27,800	21,700	14,900	64,400	0	0	0	0
		Tributary Totals	2,859,600	1,531,700	2,460,400	1,435,000	8,229,500	3,206,400	777,000	657,400	191,200	1,625,600	293,100	255,600	46,500	596,400
		Connecticut River Totals	3,359,000	3,254,000	24,883,600	23,671,600	13,510,200	12,817,200	1,022,500	895,800	2,740,800	4,659,100	934,200	817,800	2,368,000	4,120,000
		Grand Totals	6,218,600	4,785,700	27,344,000	25,106,600	21,739,700	16,023,600	1,799,500	1,553,200	2,932,000	6,284,700	1,227,300	1,073,600	2,414,500	4,716,400

& Exclusive of $1000 reduction due to Winsor Reservoir.
* Exclusive of $64,000 reduction due to Winsor Reservoir.
** Exclusive of $15,000 reduction due to Winsor Reservoir.
\# Exclusive of $52,000 reduction due to Winsor Reservoir.
\#\# Exclusive of $81,500 reduction due to Winsor Reservoir.

NOTE: 1927 Flood Losses are incomplete due to unavailable data on the Ashuelot, Chicopee, and Farmington Rivers.

21. ANNUAL DIRECT BENEFITS. - Average annual direct losses prevented by protective works are equivalent to direct benefits. Benefits to reservoirs were computed first and benefits to levees or other local protective works were computed from the residual losses, as the losses prevented up to the limiting frequency of protection. Direct benefits to reservoirs were computed for each damage zone by the following method:

a. The damage-frequency curve for each damage zone, described in Paragraph 20, was divided into component frequency ranges, the breaks being at 1, 2, and 5 percent chance of occurrence on the main stem and at 1 and 5 percent chance on the tributaries.

b. The natural average annual loss was determined for each frequency range by the method of Paragraph 20. Plots of benefit versus reduction of peak discharge were made by applying various percent reductions to the discharge-frequency curve, and computing the corresponding reduction in loss.

c. The percent reduction of peak discharge effected by each reservoir was determined for the individual frequency ranges of all the damage zones affected. The following formula was used for zones of the main stem:

$$\text{Percent Reduction} = C_w L$$

where:

C_w = percent reduction of peak discharge, provided the entire flood is stored. The computation of these values is shown in Section 1 of the Appendix.

L = Ratio of reservoir capacity in inches to flood volume in inches at index station of damage zone. It was obtained as an average value for each frequency range from the following formula:

$$L_{avg} = 1/4 \left[\frac{S}{V_B} + 2\frac{S}{V_M} + \frac{S}{V_E} \right]$$

in which:

S = Capacity of reservoir in inches.

V_B, V_M, V_E = Natural flood volume in inches, respectively for lowest, mean, and highest frequency of the frequency range.

When any V is equal to or less than S, the corresponding S/V term is kept at unity, its maximum value.

The percent reductions from tributary damage zones were computed by the method described in Paragraph 5d, Section 1 of the Appendix, using the average L for each frequency range, which was computed as shown above.

d. Benefits to reservoirs were computed by summating, for all damage zones affected, the benefits of each frequency range, as given by the curve of benefit-percent reduction. Where a reservoir affects only a portion of a zone, benefits from the curve were multiplied by the fraction of the zone affected. Benefits to reservoirs are summarized in Tables XVI and XVII.

(Table XVII on following page)

TABLE XVII

AVERAGE ANNUAL BENEFITS BY INDIVIDUAL RESERVOIRS

RESERVOIR	RIVER	DRAINAGE AREA SQUARE MILES	CAPACITY INCHES	CAPACITY ACRE FT.	TOTAL ANNUAL COST	MAIN STEM BENEFITS DIRECT	MAIN STEM BENEFITS INDIRECT	MAIN STEM BENEFITS RESTORATION	MAIN STEM BENEFITS TOTAL	TRIBUTARY BENEFITS DIRECT	TRIBUTARY BENEFITS INDIRECT	TRIBUTARY BENEFITS RESTORATION	TRIBUTARY BENEFITS TOTAL	TOTAL BENEFITS DIRECT	TOTAL BENEFITS INDIRECT	TOTAL BENEFITS RESTORATION	TOTAL BENEFITS TOTAL	RATIO OF BENEFIT TO COST
MASSACHUSETTS																		
Knightville	Westfield	164	4.5	39,300	$ 124,900	$ 43,000	$ 38,300	$ 63,100	$144,400	$25,000	$ 23,300	$ 4,500	$ 52,800	$ 68,000	$ 61,600	$ 67,600	$197,200	1.6
Easthampton	Manhan	68	6.0	21,800	68,800	24,600	21,800	32,900	79,300	0	0	0	0	24,600	21,800	32,900	79,300	1.2
Fort Morrison	Deerfield (North)	48	6.0	15,400	120,700	23,600	20,800	30,600	75,000	7,800	5,200	0	13,000	31,400	26,000	30,600	88,000	0.7
West Brookfield	Chicopee (Quaboag)	106	6.0	33,900	123,600	36,300	32,400	60,000	128,700	14,500	12,800	300	27,600	50,800	45,200	60,300	156,300	1.3
Barre Falls	Chicopee (Ware)	57	8.0	24,300	53,000	19,900	17,800	32,400	70,100	18,600	17,600	3,600	39,800	38,500	35,400	36,000	109,800	2.1
Tully	Millers (Tully)	50	8.3	22,150	39,200	24,200	21,300	32,100	77,600	18,500	16,500	2,300	37,300	42,700	37,800	34,400	114,900	2.9
Birch Hill	"	155*	6.0	49,900	162,800	76,700	67,300	94,600	238,600	48,700	40,000	12,700	101,400	125,400	107,300	107,300	340,000	2.1
Lower Naukeag	"	20	8.0	8,530	34,400	10,300	9,000	13,100	32,400	16,100	14,400	1,400	30,900	25,400	23,400	14,500	63,300	1.8
NEW HAMPSHIRE																		
Honey Hill	Ashuelot (South Br.)	70	7.0	26,200	107,900	30,900	26,900	38,100	95,900	21,500	18,100	2,900	42,500	52,400	45,000	41,000	138,400	1.3
Otter Brook	" (Otter Brk.)	47	7.0	17,500	79,100	21,000	18,200	25,500	64,700	15,800	13,200	2,300	31,300	36,800	31,400	27,800	96,000	1.2
Surry Mountain	"	100	6.1	32,500	92,000	43,300	37,600	51,600	132,500	29,500	24,600	5,000	59,100	72,800	62,200	56,600	191,600	2.1
Claremont	Sugar	245	6.0	78,400	265,100	125,300	109,800	135,500	370,400	4,500	3,900	0	8,400	129,800	113,500	135,500	378,800	1.4
West Canaan	[illegible]	80	8.0	34,100	114,600	34,700	30,900	30,700	96,300	13,200	8,600	300	22,100	47,900	39,500	31,000	118,400	1.0
Sugar Hill	Ammonoosuc	246	7.0	91,600	327,900	106,300	92,300	85,300	283,900	9,000	7,500	100	16,600	115,300	99,800	85,400	300,500	0.9
Upper 15 Mi. Falls	Connecticut	1,626	5.5	476,000	742,000	306,700	264,300	273,300	844,300	0	0	0	0	306,700	264,300	273,300	844,300	1.1
VERMONT																		
Williamsville	West	400	7.0	150,000	308,600	235,400	205,300	317,500	758,200	1,000	900	0	1,900	236,400	206,200	317,500	760,100	2.5
Cambridgeport	Saxtons	58	7.0	21,600	104,000	35,600	31,200	42,200	109,000	1,100	1,100	0	2,200	36,700	32,300	42,200	111,200	1.1
Brockway	Williams	101	6.0	32,300	150,300	65,300	57,300	72,500	195,100	0	0	0	0	65,300	57,300	72,500	195,100	1.3
North Springfield	Black	102**	6.2	33,400	116,900	59,000	51,700	67,100	177,800	12,800	12,200	1,300	26,300	71,800	63,900	68,400	204,100	1.8
Ludlow	Black	56	8.0	23,900	97,100	35,500	31,200	38,300	105,000	41,700	32,100	2,000	75,800	77,200	63,300	40,300	180,800	1.9
North Hartland	Ottauquechee	222	6.0	71,100	191,100	132,900	116,500	132,100	381,500	0	0	0	0	132,900	116,500	132,100	381,500	2.0
South Tunbridge	White (First Br.)	102	6.0	32,600	128,300	58,700	52,000	55,000	165,700	1,000	900	0	1,900	59,700	52,900	55,000	167,600	1.3
South Randolph	" (Second Br.)	63	7.0	23,500	88,100	36,700	32,500	35,100	104,300	1,200	1,000	0	2,200	37,900	33,500	35,100	106,500	1.2
Ayers Brook	" (Ayers Brk.)	30	7.0	11,200	51,500	18,000	15,900	16,900	50,800	6,300	7,300	0	13,600	24,300	23,200	16,900	64,400	1.3
Gaysville	White	226	7.0	84,300	224,900	128,800	114,000	126,600	369,400	9,400	7,700	100	17,200	138,200	121,700	126,700	386,600	1.7
Union Village	Ompompanoosuc	126	4.5	30,200	106,100	72,000	63,700	62,600	198,300	0	0	0	0	72,000	63,700	62,600	198,300	1.9
South Branch	Waits (South Br.)	45	7.0	16,800	70,600	30,200	26,600	27,300	84,100	300	200	0	500	30,500	26,800	27,300	84,600	1.2
Victory	Passumpsic (Moose)	66	8.0	28,200	60,100	29,400	25,200	21,800	76,400	6,400	6,000	0	12,400	35,800	31,200	21,800	88,800	1.5
Lyndonville	"	70	7.0	26,100	119,300	29,700	25,500	22,500	77,700	13,900	12,900	500	27,300	43,600	38,400	23,000	105,000	0.9
		4,749		1,556,790	$4,272,900													

* Exclusive of drainage area above Lower Naukeag.

** Exclusive of drainage area above Ludlow.

NOTE: Benefits computed for each reservoir separately.

22. INDIRECT LOSSES. - Indirect losses are the value of service or use lost or made necessary by reason of flood conditions, not chargeable to direct loss. They include losses of business and wages, costs of relief and similar losses, both within and without the flood area, during the period of flood and subsequent rehabilitation. It has not been possible to summate indirect losses completely or accurately, because of the difficulty experienced in estimating certain portions of the losses and the reluctance shown by many interests to give out information which may affect their credit standing. Indirect losses have been evaluated from their relation to the types of direct losses, which were determined from available data studied by methods of sampling and rational analysis.

23. DETERMINATION OF INDIRECT LOSS RATIOS. - Ratios of indirect loss to the corresponding direct losses were determined for each class of property or type of direct loss. They are discussed in approximate order of importance.

a. Industrial indirect losses. - Indirect losses related to industrial damage make up a major part of the total indirect losses. A portion of the industries contacted were able to give sufficiently complete estimates of their losses of business, wages, and other indirect losses to permit the determination of an average ratio of indirect losses. Industries sustaining direct losses of $3,628,000, or approximately one-third of industrial losses, reported indirect losses of $3,696,000 which is approximately 102 percent of the direct loss. Allowing for other losses which were not reported, indirect industrial losses will amount to approximately 120 percent of the corresponding direct losses. The following losses were considered:

(1) Loss of normal production and business, and delay in shipment inside and outside the flood area. Losses which were later made up were not included.

(2) Losses of wages or income.

(3) Extra costs of doing business.

(4) Costs of establishing temporary facilities.

(5) Loss of good will or cost or regaining lost business.

b. Commercial indirect losses are of the same character as industrial indirect losses, which are discussed above, and they were investigated in a similar manner. The total of complete reports of commercial direct losses and the corresponding indirect losses total $590,700 direct and $372,500 reported indirect. These losses, which represent about one-half of the commercial losses in the watershed, indicate a ratio of 0.63. Commercial indirect losses average approximately 70 percent of the corresponding direct losses, allowing for various unreported losses.

c. Residential indirect losses. - The more important indirect losses associated with damage to dwellings are:

(1) Cost of evacuation and emergency quarters.

(2) Loss of rent.

(3) Expenditures to alleviate distress conditions, prevention of sickness and epidemics -- Red Cross, National Guard, extra policing.

(4) Loss ot taxes due to temporary suspension.

These indirect losses were estimated for a number of typical areas in Vermont, New Hampshire, Massachusetts, and Connecticut, from the number of homes vacated on the basis of costs of evacuation varying from ten dollars per family in semi-rural areas to fifty dollars in densely populated localities. Red Cross and public health expenditures were prorated to the areas from state or county figures and the total indirect losses were compared with residential damage in the same localities. Indirect losses, computed in this manner, total $850,000, or 42 percent of $2,033,000 direct loss. These are approximately one-fourth of the total residential losses within damage zones. Residential indirect losses have been estimated at 40 percent of the corresponding direct losses.

d. Highway indirect losses. - Highway indirect losses result from the detour and delay of vehicular traffic that results from bridge and roadway washouts, as follows:

(1) Extra cost of travel due to long detours.

(2) Cost of delay or loss of time to vehicles and passengers.

(3) Losses of business to transportation and trucking companies.

(4) Losses due to non-delivery of goods.

(5) Extra cost of maintenance or reconstruction of secondary roads used for detours.

The relation to direct losses was estimated for (1) detour costs and (2) delay costs, based upon vehicular traffic counts which were available for most of the affected highways, increased distance necessary while the detour was required, and an average delay of 4 days while all the principal bridges across the Connecticut River were closed. The determination of the ratio for this type of indirect loss was made from the data of the 1936 flood as follows:

STATE	Indirect loss: Detour cost — Extra travel at $.055 per mi.	Indirect loss: Delay cost — Time lost at $1.00/vehicle hr., 8-hr. day	Total	Direct loss	Ratio indirect to direct loss
Massachusetts	$ 44,000	$2,317,000	$2,361,000	$4,774,000	49%
Connecticut	140,000	2,677,000	2,817,000	881,000	319%
New Hampshire	588,000	516,000	1,104,000	1,375,000	80%
Vermont	650,000*	300,000*	950,000	691,000	137%
Total	1,422,000	5,810,000	7,232,000	7,721,000	94%

* No traffic count available, number of vehicles estimated.

Indirect losses related to highway damage were computed at 100 percent of the direct loss to allow for some of the losses that were not included in the above determination.

c. Railroad indirect losses. - The extent of indirect losses sustained by railroads was estimated from the monthly Railroad Operating Revenue and Operating Expense sheets issued by the Association of American Railroads, after making allowance for normal seasonal fluctuation. The determination was limited to the flood of 1936 because hurricane wind and wave damage, as well as flood damage, occurred in September 1938. Losses were computed, for the two principal railroad companies operating in the flood areas, from the increase over the normal operating expenses for the months of March and April 1936, and from the loss in revenue for March. The determination was as follows:

	N.Y.,N.H. & H. Railroad	Boston & Maine Railroad
Direct damage reported by company	$420,000	$ 830,000
Increase in operating expense during March and April 1936. (From increase over normal operating ratio)	916,000	1,501,000
Indirect loss included in operating expenses	496,000	671,000
Indirect loss of revenue (Decrease from normal for March)	42,000	132,000
Total indirect loss to company	538,000	803,000
Ratio indirect to direct loss	1.28	0.97

Besides the above losses to the railroads themselves, the effects of interrupted or irregular service were widespread and causes innumerable other losses to industry, commerce, and individuals. The indirect losses were taken at 100 percent of the railroad direct losses.

f. Utility indirect losses. - Indirect losses related to utility damage include losses to industrial, residential, and commercial groups outside the flood area, by reason of disruption of service, as well as the loss of income or cost of temporary service to the utility companies themselves. Indirect losses to the utility companies, based upon profit and overhead, amount to approximately 60 percent of the direct losses. Indirect losses, due to interruption of service, to groups outside the flood were studied by analyses of several representative power utilities and the areas they serve. These indirect losses were found to total four times the indirect loss to the original companies and several times the direct loss. The total utility indirect losses were conservatively placed at 100 percent of the corresponding direct loss.

g. Agricultural indirect losses include losses due to exodus, costs of relief, and other losses similar to residential property. Also, reduced crop yield, as a result of deposits and erosion of topsoil by a great flood, is extended over several years until the land returns to normal fertility. These losses were estimated for individual farms and summated for representative river basins. They were found to vary from 12 percent of the direct losses for low-type agricultural areas to 34 percent for highly developed market garden and tobacco lands. The indirect losses related to agricultural damage have been computed at 20 percent of the corresponding direct loss.

h. Public indirect losses. - Flooding of post offices, schools, and institutions, playgrounds, parks, and other public properties result in substantial indirect losses to the governmental agencies and to the public by interruption of their services. These indirect losses have been estimated at approximately 50 percent of the public direct losses.

24. <u>AVERAGE ANNUAL INDIRECT LOSSES</u>. - The ratios established for indirect losses to each type of direct loss were as follows:

Residential . 0.40	Railroad 1.00
Commercial. . 0.70	Highway 1.00
Industrial. . 1.20	Agricultural . . 0.20
Utility . . . 1.00	Public 0.50

By application of these ratios to the direct recurring losses of each type, and by weighting these as they occurred in the flood of record, a percentage was determined for each damage zone. Indirect losses were computed by application of this constant percentage to the direct losses of each reach. Indirect benefits were determined by application of the same percentage to the direct benefits. There are other important losses of an intangible nature which were not included in the above determination. Determinable indirect losses and benefits are summarized in Table XVI.

Depreciation Losses - Restoration Benefits

25. <u>GENERAL</u>. - In addition to the direct and indirect losses which are discussed above, recent floods have caused important depreciation losses. Depreciation losses are the loss of value and utility of real estate, beyond that deducible from direct and indirect losses. These decreases below the normal value of property have resulted from the flood experiences of March 1936 and September 1938. Normal value, which is regulated by the experienced cycle of floods, was taken as the value before the major flood of 1936, and decreases during the period from 1935 to 1939 were observed. The depreciation losses may be further increased by the occurrence of other great floods, and may be diminished somewhat by the occurrence of a long period with no floods. They are not recurring as are the direct and indirect losses. Since the recent extraordinary floods, decreases in value have become evident in some of the

following ways:

a. Complete loss - sacrifice and abandonment of property.

b. Reduced value for sale, rental, mortgage, and taxation.

c. Permanent losses of business and good will.

d. Considerable mortgaged-property reverts to mortgagees.

e. Curtailment of industrial expansion or new development.

f. Exodus of industries and people from flood area, and abandonment of plants, facilities, and homes; often exodus would be more general were not flood protection contemplated.

g. Tendency to withdraw capital from flood area and stop credit for repair or construction.

h. Because of risk of flood damage, business interruptions and further decrease in property values; any new capital introduced demands greater return on investment.

i. Reduction in utility:

Lower use of basements and grounds.

Lower type of use of crop lands (tobacco to onions to hay).

Lower class of tenant.

j. Degradation and tendency toward blighted areas because of lower-class tenant or owner willing to remain in flood area.

Decreases in real estate values in the flooded areas of Hartford and Springfield have reached staggering proportions as a result of the two great floods. Although the real estate market outside the flood areas is relatively good, considering economic conditions for the past ten years, there is absolutely no market for any class of property within the areas. Assessed valuations have been reduced by as much as 50 percent on some properties. Not only do banks refuse to grant loans, but also existing loans are being liquidated on a distress basis. Many industrial concerns have sustained large permanent losses of business. The owners of some of these concerns have endeavored to dispose of these properties in order to escape the hazards of floods, only to find that floods have reduced the value of the properties to such an extent that little sale value exists. All types of property have become degraded as to occupancy and use. The losses in real estate values within the flood areas can be measured with fair accuracy, but the actual loss is extended much further, inasmuch as the contiguous non-flooded areas gradually become part of the flood plain with regard to occupancy and use.

26. EVALUATION OF DEPRECIATION LOSSES. - Annual depreciation losses were computed from the depression in values that will remain if flood protection is not provided, based upon observed decreases from the normal value prior to 1936.

a. Normal real estate valuation. - Summarized in Table XVIII is the value of property previous to the major flood of 1936. Valuations were based upon assessments adjusted to represent true value in each locality. The pre-flood value and development in known flood areas were found to be already based upon recognition of normal floods and were considerably below the level of equivalent unflooded property.

b. Decreases in value were determined, allowing for economic changes, from a wide range of sources:

(1) True sales from real estate brokers to determine loss in market value.

(2) Amount of reduction in assessed values or abatements in taxes, ascertained from local assessors.

(3) Opinions of bankers, real estate operators, and other qualified individuals and organizations as to the effect of recent major floods upon the market or mortgage value of property.

(4) Opinions of owners, tenants, and officials of industrial plants as to loss in market, rental, or utility value.

On the basis of the above facts and opinions for each locality or important property, experienced appraisers determined the decreases from preflood value, between the extremes of exaggerated depreciation from opinions of bankers and real estate operators to depreciation less than the actual amount from assessors. These decreases in value were reduced to exclude the capitalized value of annual direct and indirect losses wherever real estate values prior to 1936 did not already reflect flood experience. The amount of the reduction ranged from 1.5 percent of valuation in the highly developed areas of the lower valley to 20 percent in the small urban or industrial areas of the upper valley. The existing depreciation, determined in this manner, amounts to approximately $83,739,000 for real estate valued at $393,498,000 prior to the recent floods as summarized in Table XVIII. This represents an average decrease, in the flood area, of 6.9 percent in Vermont, 8.1 percent in New Hampshire, 21.4 percent in Massachusetts, and 23.6 percent in Connecticut as a result of the floods of 1936 and 1938. In a few instances, decreases initiated by the flood of 1927 on upper Vermont and New Hampshire tributaries have been included if the loss has not already become permanent.

c. Annual depreciation losses were computed upon the basis of (1) an average recoverable loss during the 50-year life of protective works equal to one-half the existing depreciation, determined above, and (2) an annual loss of 5 percent to the property owners and a 2 percent tax loss to the community. Annual depreciation losses are summarized in Table XVI.

27. RESTORATION BENEFITS. - Adequate flood protection is the only means of restoring the depreciated value of real estate and of enabling the property to retain the value it had previous to the 1936 flood. Benefits from recovery of the annual depreciation losses determined above were credited to proposed protective works in proportion to the value of real estate receiving complete protection. This proportion was determined from curves of real estate value versus stage or discharge,

TABLE XVIII

DEPRECIATION AND VALUATION DATA, AND
POTENTIAL INCREASES IN LAND VALUES
CONNECTICUT RIVER WATERSHED

RIVER	DAMAGE ZONE	STATE	REAL ESTATE VALUATION, PREFLOOD. MAXIMUM EXPERIENCED FLOOD AREA	REAL ESTATE VALUATION, MAXIMUM FLOOD AREA*	REAL AND PERSONAL PROPERTY VALUATION, MAXIMUM FLOOD AREA*	EXISTING DEPRECIATION OF REAL ESTATE FROM FLOODS OF 1936, 1938 **	POTENTIAL INCREASE OF LAND VALUES, WITH PROTECTION
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connecticut	C-1	Vt.-N.H.	$ 598,000	$ 975,000	$ 1,364,000	$ 5,700	$ 0
"	C-2	Vt.-N.H.	568,000	761,000	1,044,000	5,500	0
"	C-3	Vt.-N.H.	2,348,000	3,102,000	4,895,000	127,100	0
"	C-4	Vt.-N.H.	1,318,000	2,018,000	3,418,000	4,500	0
"	C-5	Vt.-N.H.	3,020,000	4,894,000	8,000,000	195,700	0
"	C-6	Vt.-N.H. & Mass.	288,000	402,000	536,000	4,100	0
"	C-7	Mass.	31,771,000	47,211,000	66,328,000	6,500,000	828,000
"	C-8	Mass.	132,759,000	162,780,000	264,607,000	32,857,000	2,754,000
"	C-9	Conn.	4,300,000	7,610,000	18,140,000	430,000	122,000
"	C-10	Conn.	156,524,000	260,700,000	267,983,000	38,210,000	8,126,000
Totals for	Connecticut R.		333,494,000	490,453,000	636,395,000	78,339,600	11,830,000
Passumpsic	1 a	Vt.	214,000	281,000	331,000	0	0
"	1 b	Vt.	2,040,000	2,334,000	3,548,000	127,500	0
"	1 c	Vt.	1,190,000	1,246,000	1,996,000	68,000	0
"	1 d	Vt.	449,000	494,000	583,000	0	0
Stevens	2 a	Vt.	30,000	105,000	154,000	0	0
Wells	3 a	Vt.	549,000	613,000	891,000	34,000	0
Ammonoosuc	4 a	N.H.	13,000	865,000	1,718,000	0	0
"	4 b	N.H.	259,000	500,000	1,002,000	14,000	42,000
"	4 x	N.H.	323,000	630,000	942,000	0	0
"	4 y	N.H.	42,000	250,000	372,000	0	0
Waits	5 a	Vt.	34,000	135,000	208,000	3,100	0
White	7 a	Vt.	107,000	186,000	216,000	3,400	0
"	7 b	Vt.	15,000	30,000	39,000	0	0
"	7 c	Vt.	40,000	144,000	184,000	2,600	0
"	7 d	Vt.	305,000	420,000	570,000	11,900	0
"	7 e	Vt.	190,000	290,000	400,000	0	0
"	7 v	Vt.	157,000	197,000	264,000	4,800	0
"	7 w	Vt.	0	0	0	0	0
"	7 x	Vt.	0	330,000	435,000	3,100	0
"	7 y	Vt.	172,000	339,000	479,000	0	0
Mascoma	8 a	N.H.	149,000	367,000	586,000	4,400	0
"	8 b	N.H.	1,600,000	1,184,000	2,784,000	43,000	0
Ottauquechee	9 w	Vt.	835,000	1,146,000	1,889,000	27,800	0
Sugar	10 a	N.H.	15,000	29,000	63,000	0	0
"	10 b	N.H.	1,746,000	3,617,000	7,174,000	0	39,000
"	10 c	N.H.	3,000	31,000	45,000	0	0
"	10 w	N.H.	233,000	853,000	1,547,000	3,600	0

RIVER	DAMAGE ZONE	STATE	REAL ESTATE VALUATION, PREFLOOD, MAXIMUM EXPERIENCED FLOOD AREA	REAL ESTATE VALUATION, MAXIMUM FLOOD AREA*	REAL AND PERSONAL PROPERTY VALUATION, MAXIMUM FLOOD AREA*	EXISTING DEPRECIATION OF REAL ESTATE FROM FLOODS OF 1936, 1938 **	POTENTIAL INCREASE OF LAND VALUES, WITH PROTECTION
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Black	11 a	Vt.	$ 905,000	$ 1,788,000	$ 2,637,000	$ 96,000	$ 0
"	11 b	Vt.	150,000	151,000	201,000	6,200	0
"	11 c	Vt.	1,516,000	2,483,000	3,733,000	124,000	0
Saxtons	12 a	Vt.	18,000	454,000	575,000	0	0
West	13 a	Vt.	118,000	140,000	185,000	0	0
"	13 y	Vt.	289,000	383,000	443,000	23,400	0
"	13 z	Vt.	265,000	314,000	374,000	0	0
Ashuelot	14 a	N.H.	186,000	394,000	525,000	29,900	0
"	14 b	N.H.	4,180,000	8,841,000	14,186,000	700,000	86,000
"	14 c	N.H.	441,000	634,000	1,123,000	0	0
"	14 f	N.H.	552,000	810,000	1,532,000	0	0
"	14 m	N.H.	57,000	69,000	112,000	8,000	0
"	14 x	N.H.	231,000	262,000	499,000	25,100	0
Millers	15 c	Mass.	1,049,000	1,210,000	2,126,000	154,300	0
"	15 e	Mass.	1,051,000	2,641,000	6,543,000	158,500	0
"	15 g'	Mass.	7,757,000	9,958,000	15,289,000	716,000	0
"	15 h'	Mass.	1,888,000	1,892,000	4,081,000	194,000	0
"	15 d	Mass.	6,000	17,000	22,000	0	0
"	15 f	Mass.	0	0	0	0	0
"	15 x	Mass.	608,000	617,000	1,188,000	74,300	0
Deerfield	16 u	Mass.	733,000	1,016,000	1,803,000	0	0
"	16 y	Mass.	1,145,000	1,821,000	2,765,000	0	0
"	16 w	Mass.-Vt.	17,000	52,000	72,000	0	0
"	16 x	Mass.-Vt.	778,000	974,000	1,342,000	26,800	0
"	16 y	Vt.	26,000	116,000	185,000	0	0
"	16 z	Vt.	103,000	447,000	716,000	12,700	0
Chicopee	22 a	Mass.	0	320,000	330,000	0	0
"	22 b	Mass.	8,986,000	9,622,000	13,698,000	825,000	565,000
"	17 a	Mass.	160,000	409,000	915,000	0	0
"	21 a	Mass.	202,000	387,000	569,000	9,700	0
"	21 b	Mass.	968,000	1,325,000	2,314,000	0	0
"	17 b	Mass.	7,160,000	14,106,000	33,594,000	912,000	237,000
Westfield	18 a	Mass.	11,000	95,000	165,000	0	0
"	18 b	Mass.	1,650,000	15,009,000	22,795,000	329,000	252,000
"	18 c	Mass.	190,000	280,000	525,000	0	0
"	18 v	Mass.	71,000	103,000	153,000	700	0
"	18 w	Mass.	451,000	705,000	1,308,000	9,800	0
"	18 x	Mass.	7,000	11,000	16,000	0	0
Farmington	19 u	Mass.	48,000	101,000	119,000	0	0
"	19 v	Conn.	556,000	1,406,000	2,176,000	0	0
"	19 w	Conn.	1,111,000	1,956,000	3,040,000	71,000	0
"	19 x	Conn.	1,520,000	1,777,000	2,919,000	179,000	0
"	19 y	Conn.	2,134,000	4,374,000	6,442,000	362,800	0
Tributary Totals			60,004,000	106,086,000	181,755,000	5,399,400	1,221,000

TABLE XVIII (Cont'd)

RIVER	DAMAGE ZONE	STATE	REAL ESTATE VALUATION, PREFLOOD, MAXIMUM EXPERIENCED FLOOD AREA	REAL ESTATE VALUATION, MAXIMUM FLOOD AREA*	REAL AND PERSONAL PROPERTY VALUATION, MAXIMUM FLOOD AREA*	EXISTING DEPRECIATION OF REAL ESTATE FROM FLOODS OF 1936, 1938 **	POTENTIAL INCREASE OF LAND VALUES, WITH PROTECTION
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total real and personal property					818,150,000		
Tax exempt property affected (public and highway)					57,551,000		
Railroad property affected (approximate)					20,330,000		
Totals			393,498,000	596,539,000	896,031,000	83,739,000	13,051,000

* Area flooded by flood having 0.1 percent chance of occurrence.
** Exclusive of direct and indirect loss; includes some effect of the 1927 flood.

prepared by allocating valuations to areas successively flooded up to the flooded area of the flood having a 0.1 percent chance of occurrence. Annual restoration benefits to the reservoirs of the Revised Comprehensive Plan total $2,414,000, as summarized in Tables XVI and XVII.

Increases in Land Value - Enhancement Benefits

28. DEFINITION. - Benefits to flood control will result from increases in the value of idle or partially developed lands, above the level prevailing prior to the 1936 flood, where development has been retarded by floods. These increases will result from the more productive use of the land, which will follow protection.

29. ESTIMATE OF POTENTIAL INCREASE IN LAND VALUE. - The increase was computed as the difference between present and potential land values in the area affected by floods before 1936. Present values were based upon the price level and usage prior to the flood of March 1936 as determined from assessments, sales, and properties offered for sale in the area. Potential value is the probable value of the protected land taken after a long period, 20 to 25 years. To eliminate development costs in the various areas, potential value was taken as the fair value before development takes place, as determined from weighing of the following considerations:

a. Direction of city growth (trend),

b. Location of property - proximity to developed centers,

c. Accessibility - railroad and main highways,

d. Adaptability for certain purposes,

e. Neighborhood improvements,

f. Topographical conditions,

g. Possibility of future growht,

h. Availability of other undeveloped area,

i. "Highest and best use" - most productive use over a reasonably long and sustained period,

j. Zoning ordinance restrictions.

Table XIX shows the net increases anticipated from complete flood protection.

30. ENHANCEMENT BENEFITS. - The annual benefit throughout the assumed 50-year economic life of protective works was conservatively computed at 5 percent of the potential net increase in land value for areas where complete protection is provided against a flood having a 0.1 percent chance of occurrence. Complete protection will be provided by the approved levees, and annual benefits of $550,100 will accrue, equivalent to the potential increase of $11,003,000 shown in Table XIX. Protection of the Springdale area by the proposed Holyoke levee should result in a net increase in land value of at least $465,000, or $23,300 annually. Complete protection against an extreme flood has not been recommended for other localities, and potential increases in land value equal to $1,583,000, or $791,500 annually, have not been credited to the recommended plan of protection, although a large portion of the enhancement benefits would actually accrue because of the high degree of protection provided to these areas by reservoirs.

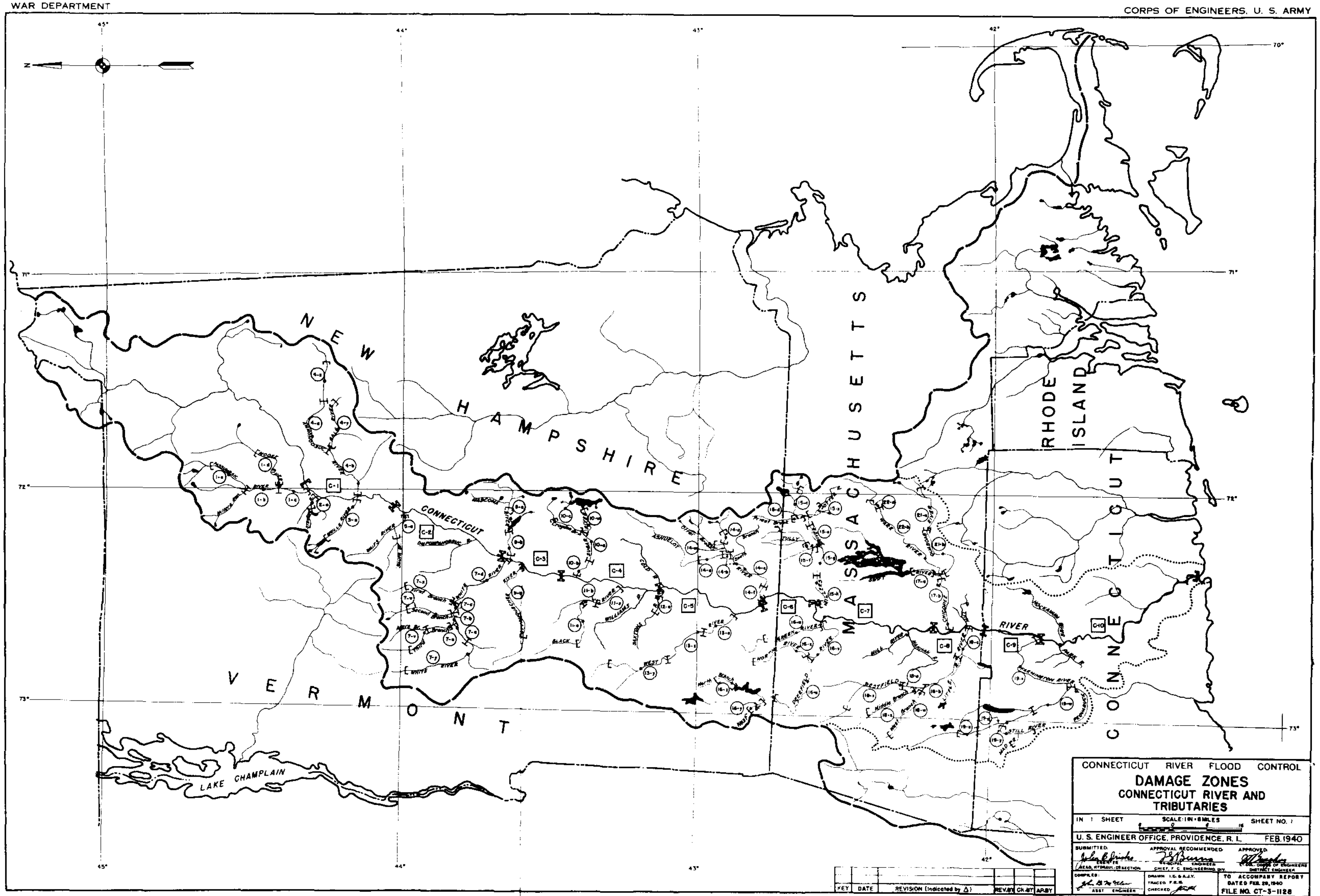
TABLE XIX

POTENTIAL INCREASES IN LAND VALUES
CONNECTICUT RIVER WATERSHED

LOCATION				DAM-AGE ZONE	AREA, ACRES	BEFORE PROTECTION						AFTER PROTECTION						NET POTENTIAL INCREASE OF VALUE**
	CITY	STATE	RIVER			AVERAGE PRE-FLOOD VALUE				TOTAL VALUE		AVERAGE POTENTIAL VALUE				TOTAL POTENTIAL VALUE	POTENTIAL USE	
						ACRES	UNIT VALUE*	FRONT FEET	UNIT VALUE*			ACRES	UNIT VALUE*	FRONT FEET	UNIT VALUE*			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)		(12)	(13)	(14)	(15)	(16)	(17)	(16)
									APPROVED LEVEE AREAS									
1	NORTHAMPTON	MASS.	CONN.	7	31	26	$ 140	2,200	$ 10	$ 25,600		26	$ 870	2,200	$ 75	$ 187,600	MIXED	$ 162,000
2	CHICOPEE	MASS.	"	8	297	266	240	13,500	7	157,700		260	1,387	13,500	80	1,449,700	"	1,292,000
3	SPRINGFIELD	"	"	8	118	112	1,605	2,700	10	206,700		112	4,167	2,700	68	650,700	COMM. - IND.	444,000
4	WEST SPRINGFIELD	"	"	8	253	245	2,189	3,400	40	673,300		245	4,412	3,400	179	1,691,000	" "	1,018,000
5	HOLYOKE	"	"	7	-	-	-	-	-	-		-	-	-	-	-	-	0
6	HARTFORD	CONN.	"	10	1,185	1,185	1,020	-	-	1,209,000		1,185	6,590	-	-	7,810,000	" "	6,601,000
7	EAST HARTFORD	"	"	10	377	356	86	9,100	23	239,600		356	1,857	9,100	117	1,726,200	MIXED	1,486,000
	TOTALS, APPROVED LEVEE AREAS				2,261					2,511,900						13,515,200		11,003,000
									OTHER AREAS									
8	NORTHAMPTON	MASS.	"	7		381	267	-	-	102,000		381	792	-	-	302,000	"	200,000
9	HOLYOKE	"	"	7	52	49	6,265	1,500	20	337,000		49	11,775	1,500	150	802,000	COMM. - IND.	465,000
10	WINDSOR	CONN.	"	9	320	320	356	-	-	114,000		320	738	-	-	236,000	MIXED	122,000
11	WETHERSFIELD	"	"	10	11	11	272	-	-	3,000		11	3,910	-	-	43,000	RES.	40,000
12	LISBON	N.H.	AMMONOOSUC	4R	73	73	657	-	-	48,000		73	1,233	-	-	90,000	RES. - AGR.	42,000
13	CLAREMONT	"	SUGAR	10R	96	96	312	-	-	30,000		96	718	-	-	69,000	" "	39,000
14	KEENE	"	ASHUELOT	14B	201	201	173	-	-	34,800		201	600	-	-	121,000	IND. - RES.	86,000
15	WARE	MASS.	CHICOPEE	22B	22	22	900	-	-	19,000		22	1,590	-	-	35,000	RES.	16,000
16	WARE	"	"	22R	5	-	-	(INCLUDING BUILDINGS)		247,000		5	-	(INCLUDING BUILDINGS)		796,000	IND.	549,000
17	CHICOPEE FALLS	"	"	17R	5	-	-	(INCLUDING BUILDINGS)		320,000		5	-	(INCLUDING BUILDINGS)		557,000	"	237,000
18	WESTFIELD	"	WESTFIELD	13B	109	109	908	-	-	99,000		109	3,220	-	-	351,000	MIXED	252,000
	TOTALS, OTHER AREAS				894					1,353,800						3,402,000		2,048,000
	GRAND TOTALS				3,155					3,865,700						16,917,200		13,051,000

* AVERAGE UNIT VALUES PER ACRE AND PER FRONT FOOT, 100 FEET DEEP.
WEIGHTED AVERAGE OF ESTIMATED UNIT VALUES APPLICABLE TO EACH PARCEL.

** CREDITED TO PROPOSED PROTECTIVE WORKS ONLY WHERE COMPLETE PROTECTION PROVIDED.



APPENDIX PLATE NO. 12

SECTION 3

POLLUTION

POLLUTION

SECTION 3 - POLLUTION

General

1. INTRODUCTION. - In the Connecticut River Watershed, pollution abatement is essential to balance industrial uses and recreational demands for purity. Since the main river is an interstate stream, cooperation, chiefly between Massachusetts and Connecticut, is necessary. These two states, both heavily populated and industrialized, have eight times the population density of similar areas in the watershed in New Hampshire and Vermont. Concerted efforts to eradicate pollution have resulted in the completion of a modern sewage-disposal plant at Hartford, Connecticut, while the second largest source of pollution, at Springfield, Massachusetts, will soon be cared for by works now under construction. Other improvements at smaller municipalities are numerous. The situation with respect to industrial and refuse pollution is not so serious as along other New England rivers.

2. SCOPE. - This section of the Appendix describes the general sanitary conditions along the various streams in the Connecticut River Watershed; lists the sources, types, and quantities of polluting substances; and outlines the remedial measures now in operation, under construction, or contemplated. Studies were made of existing and proposed pollution abatement statutes, water analyses, and reports of other agencies. Interviews and conferences with state officials furnished the information needed for bringing data up to date. The effect of flood control works on pollution problems is discussed.

3. PREVIOUS REPORTS. - Preparation of pollution studies for the Connecticut Basin was facilitated by the numerous recent reports made available by state agencies and New England planning authorities. Under sponsorship of the Massachusetts Department of Public Health, personnel of the Work Projects Administration are preparing reports on pollution

sources in the various watersheds of the Commonwealth, including the Connecticut, Deerfield, Millers, Chicopee, and Westfield Basins. To date only the Deerfield valley report[1] has been printed, but the sponsors have allowed use of preliminary data which are to be incorporated in the remaining reports. For the portion of the basin in Connecticut, reports of the State Water Commission, particularly their "Watershed Pollution Study"[2] were utilized. No comprehensive state documents concerning the upper part of the basin, in New Hampshire and Vermont, were found, but tabulations[3] of the New England Regional Planning Commission were available for these less densely populated areas. A complete list of reports, used in this section of the Appendix, is given in the bibliography on Page 153 following.

4. DESCRIPTION OF BASIN. - The location, size, and topography of the main stream and its tributaries are described in the reports on the Connecticut River published as House Documents No. 455, Seventy-fifth Congress, second session, and No. 412, Seventy-fourth Congress, second session. A description of the sanitary condition of the various streams of the basin follows in Paragraphs 15 to 23 of this section of the Appendix.

5. POPULATION. - According to the 1930 Federal Census, the Connecticut River Watershed in New Hampshire and Vermont, having a population density of 30 per square mile, is less than one-eighth as thickly inhabited as the Massachusetts-Connecticut portion, which has a density of 247 per square mile. Over two-thirds of the 1,230,000 population is urban with nearly all cities located in the southern part of the valley. Since the 1930 census, estimates indicate that increases have occurred in the urban and suburban areas, particularly in the industrial part of the basin around Springfield, Massachusetts, and Hartford, Connecticut. Other than in these urban areas, population is well-distributed among

the numerous small villages along the river branches, with a gradual lessening in concentration to the northward. Of the several relationships which may be derived between population and stream pollution, most evident is the fact that the more heavily populated towns have the more urgent and complicated problems of waste disposal. Throughout the watershed nearly all of the larger communities are sewered. All do not have treatment plants. Direct pollution by sewage results. Waterway pollution is directly proportional to population density -- the more densely populated the area, the higher the sewage concentration in the streams carrying off the wastes. Fortunately the populated zones are well-spaced along the river so that some self-purification is effected between pollution sources. The chance for complete decomposition and oxidation is greater when sewage is being discharged through several small outlets than when it flows from one large outfall. Small individual discharges also result in less objectionable local conditions at the outfalls.

6. POLLUTION LAWS. - The Connecticut River Watershed, including areas in the Province of Quebec and four states, and containing an important navigable waterway, is governed by several pollution abatement laws, both Federal and State. Streams preempted for water-supply use are safeguarded by laws enforced by the various state health departments. The statutes in effect are outlined in the following paragraphs on pollution legislation.

a. Federal. - The navigable portion of the Connecticut River, that from Long Island Sound to Hartford, is directly subject to Federal navigation laws, whereas other portions of the watershed are only indirectly concerned with provisions of the "Laws for the Protection and Preservation of the Navigable Waters of the United States" as embodied in the River and Harbor Act approved March 3, 1899. Section 13 of this law makes it illegal to discharge

> "either from or out of any ship, barge, or other floating craft of any kind or from the shore, wharf, manufacturing establishment, or mill of any kind, any refuse matter of any kind or description whatever other than that flowing from streets and sewers and passing therefrom in a liquid state, into any navigable water of the United States, or into any tributary of any navigable water from which the same shall float or be washed into such navigable water; and it shall not be lawful to deposit, or cause, suffer, or procure to be deposited material of any kind in any place on the bank of any navigable water, or on the bank of any tributary of any navigable water, where the same shall be liable to be washed into such navigable water, either by ordinary or high tides, or by storms or floods, or otherwise, whereby navigation shall or may be impeded or obstructed . . ."

b. State. - In the upper portion of the watershed, laws are designed primarily for protection of the recreational and water-supply facilities of lakes and ponds, whereas in Massachusetts and Connecticut the ultimate aim is the attainment of a stream-purity balance between the numerous usages such as sewage dilution, navigation, recreation, industrial processing, and water supply. Because of greater population densities in the lower valley, laws there are necessarily more stringent and comprehensive. Much of the data on state statutes is from the 1939 report[4] of the Special Advisory Committee on Water Pollution. A digest of certain of these laws follows:

(1) New Hampshire. - The Act of March 1, 1933, amending Chapter 141 of title XV, Public Health, includes the following provisions:

(a) Section 3 prohibits the wilful pollution of any waters used as a source of water supply except that it does not apply to waste arising from lumbering business or to manufacturing if located more than four miles from point of diversion.

(b) Section 20 prohibits construction of any sewage-disposal system without first submitting detailed plans to the State Board of Health and securing its approval.

(c) Section 32 prohibits discharge of sewage or other deleterious wastes from any factory, hotel, boarding house, commercial establishment, or camp into any stream, not hitherto polluted, without approval of plans by the board.

(d) Regulation 2 of the board prohibits pollution of uncontaminated public waters, whether or not sources of water supply.

(2) Vermont. - In addition to special acts which relate to prevention of pollution of certain named lakes, the General Laws of Vermont contain the following provisions:

(a) Section 6197 provides that the State Board of Health shall advise and consult with municipal officers in regard to drainage, water supply, and sewerage of towns and villages.

(b) Section 7029 prohibits discharge of sewage or other polluted matter into the waters of a pond or lake having an area of 1000 acres or more and lying wholly within Vermont.

(c) Section 6986 prohibits deposit of edging or slabs into any stream and prohibits the owner of any mill set up after August 1, 1913, from depositing any mill refuse into streams.

(3) Massachusetts. - There is no law in Massachusetts empowering any state agency to order abatement of pollution, excepting oil pollution. Chapter 111, Section 17, of the Massachusetts General

Laws, as amended in 1937, follows:

> "The department (of Public Health) shall consult with and advise the officers of towns and persons having or about to have systems of . . . sewerage, . . . as to the best method of disposing of their . . . sewage with reference to the existing and future needs of other towns or persons which may be affected thereby. It shall also consult with and advise persons engaged or intending to engage in any manufacturing or other business whose . . . sewage may tend to pollute any inland water as to the best method of preventing such pollution, and it may conduct experiments to determine the best methods of the purification or disposal of . . . sewage. No person shall be required to bear the expense of such consultations, advice or experiments. Towns and persons shall submit to said department for its advice and approval their proposed system of . . . the disposal of . . . sewage, and no such system shall be established without such approval. All petitions to the general court for authority to introduce a system of . . . sewerage shall be accompanied by a copy of the recommendation, advice and approval of said department thereon. The department may after a public hearing require a city or town . . . to make such improvements relative to any existing treatment works as in its judgment may be necessary for the protection of the public health."

Study of this statute reveals that a city or town, although fully aware of the urgent need of a system of collecting-sewers or a treatment plant, is under no compulsion to construct such works. If they are to be constructed, plans must be approved by the Department of Public Health. However, once such a plant is in operation, the department has authority to compel enlargements, improvements, or changes to be made if the desired degree of purification is not being attained. If the department determines that the unsatisfactory operation of a disposal plant is due to manufacturing wastes it may prohibit or regulate the entrance thereof or require treatment of said wastes.

(4) <u>Connecticut</u>. - The State Water Commission, under provisions contained in Chapter 142 of the General Statutes, has authority to compel treatment of wastes and can act against establishment of any new source of pollution. Section 2557 states,

> "If, upon hearing, the commission shall find that any person, firm or corporation is polluting the waters of the state, it may make an order directing such person, firm or

corporation to use or to operate some practicable and reasonably available system or means which will reduce, control or eliminate such pollution having regard for the rights and interests of all persons concerned, provided the cost of installation, maintenance and operation thereof shall not be unreasonable or inequitable. Such order shall specify the particular system or means to be used or operated; provided, if there shall be more than one such practicable and reasonably available system or means, such order shall give to such person, firm or corporation the right to choose which one of such systems or means shall be used or operated."

Section 2559 is as follows:

"No person, firm or corporation shall create, establish, cause or maintain any source of pollution not existing June 23, 1925, provided said (State Water) commission, after hearing and investigation, upon application of any person, firm or corporation, may issue such order relating to any pollution as it shall find will best serve the public interest."

Chapter 141, Section 2547, conferring pollution abatement authority on the State Department of Health, states,

"No person, corporation or municipality shall place in or permit to be placed in, or discharge or permit to flow into, any of the waters of the state, any sewage prejudicial to public health. The state department of health may investigate all points of sewage discharge and may examine all existing or proposed public sewerage systems and refuse disposal plants, and may compel their operation in a manner which shall protect the public health or may order their alteration, extension and replacement when necessary for the protection of public health, and the qualifications of the operators of sewage treatment plants shall be subject to the approval of the state department of health. No public sewerage system or refuse disposal plant shall be built until the plan or design of the same shall have been filed with the state department of health and approved by said department, and no such system or plant shall be built, extended or replaced, the effluent or discharge from which may or shall directly or indirectly mingle or come in contact with the waters of the state until the plan for the same shall have been approved by the state water commission under the provisions of Chapter 142."

7. OIL POLLUTION LAWS.

a. Federal. - Public Document 238, Sixty-eighth Congress, first session, the "Oil Pollution Act of 1924", deals specifically with deposition of oil from vessels on coastal navigable waters, such as the Connecticut River from Hartford Memorial Bridge to Long Island Sound. The river is extensively used during summer months for pleasure boating, with yacht clubs at East Hartford, Wethersfield, Middletown, and Essex, Connecticut.

b. State. - Section 59 of the Massachusetts General Laws, Chapter 91, is the only state law regulating oil pollution in the Connecticut Basin. The law states that -

> "Whoever pumps, discharges or deposits, or causes to be pumped, discharged or deposited, into or on the waters of any lake or river or into or on tidal waters and flats, any crude petroleum or any of its products or any other oils or any bilge water or water from any receptacle containing any of said substances, in such manner and to such extent as to be a pollution or contamination of said waters or flats or a nuisance or be injurious to the public health, shall be punished by a fine of not more than five hundred dollars; but this section shall not be construed to prohibit the use of oil for the extermination of mosquitoes or other insects."

8. LAWS ON POLLUTION OF WATERWAYS BY REFUSE. - The Federal law covering this type of pollution is contained in Section 13 of the River and Harbor Act referred to in Paragraph 6a above. Regulation 3 of the New Hampshire health board prohibits the dumping of refuse, so that it can be carried into the state's public waters. It does not apply to sewage and industrial wastes discharged into already polluted waters. The Connecticut law is embodied in Chapter 142, Section 2560, which states,

> "No person or municipal or private corporation shall deposit any garbage, domestic refuse or other material of like nature in the waters of any river, stream, pond, lake or tidal waters of this state or . . . on any land within a distance of fifty feet of the high-water mark of any such waters or in any place where storm or high water may carry such material to an adjacent waterway . . ."

9. POLLUTION ABATEMENT ACTIVITIES.

a. Federal. - The Federal Government has undertaken no special pollution abatement measures for the Connecticut River Watershed other than the enforcement of the existing laws.

b. Interstate cooperation. - Because of the interstate nature of the Connecticut River Watershed, any general improvement program must depend in part on cooperation between the four states concerned, with emphasis on cooperation between Massachusetts and Connecticut where the problem is more acute. In New Hampshire, Chapter 16, Laws of 1937, authorizes the board of health, at the request of the health department of any adjoining state, to make rules and regulations for the protection of the purity of interstate waters used for public water supply of such adjoining state. Similar legislation is embodied in Section 595d of the Connecticut General Laws. In 1935 the General Assembly of Connecticut passed Special Act 527 authorizing appointment of a commission to deal with the Federal Government and other New England states in such problems as the elimination of pollution. In 1936 the Massachusetts Legislature authorized its state planning board to enter into compacts with the Federal Government and with other states for the development and improvement, including elimination of pollution, of its interstate waterways. To date no formal interstate pollution abatement compacts have been entered into for the Connecticut River Basin.

c. New Hampshire. - Broad pollution abatement powers are conferred on the State Board of Health only for streams hitherto unpolluted or streams used for water-supply purposes. The board functions chiefly in an advisory capacity, conferring with towns and cities as to pollution problems, and approving plans for sewerage systems and treatment plants. Protection of streams and lakes used for recreational purposes is considered of paramount importance.

d. Vermont. - In a manner similar to that practiced in New Hampshire, the Vermont Department of Public Health has general supervision of waterways used for water supply. If the public health is endangered, the department may, after a hearing, order removal of the cause of pollution. Towns, villages, or persons are advised in the disposal of sewage with reference to existing and future needs of other towns which may be affected. Manufacturing concerns from which drainage might pollute water are advised as to the best methods of prevention. In 1938 a state survey of town sewer systems was undertaken. Upon completion of this survey, the State hopes to investigate the extent of pollution of streams and bodies of water in Vermont.

e. Massachusetts. - House Document No. 1200[5] states,

> "While the present Massachusetts laws have assisted greatly in protecting most of the streams and tidal waters of this Commonwealth, experience shows that they give little or no assistance in preventing pollution of interstate streams. Unfortunately, in some cases, they actually prevent action by the Department (of Public Health), as in the case of the Connecticut . . . River. Some who have studied this problem would classify all streams and set up laws to keep them under classifications, such as recommended by the research and engineering committee appointed to facilitate the drafting of a tri-state agreement between New York, Connecticut and New Jersey to protect the tidal waters of these States."

A Massachusetts commission, appointed to study and investigate public health laws and policies, while not recommending strict classification of streams, favored limited additional mandatory powers conferred on the Department of Public Health. In 1938 an act was introduced to the Massachusetts Legislature to enable the Department of Public Health to order any city or town bordering the Connecticut River to install, maintain and operate sewage-disposal plants. The bill, however, was not enacted, the Legislature being loath to confer additional mandatory powers which might be used to force expenditures for improvement projects. While the department has only limited enforcement powers, it has actively urged communities to install treatment works where needed, and improvements are being made where economic conditions permit.

f. Connecticut. - The State Water Commission has legal right to conduct hearings to establish the facts regarding any certain source of pollution and to issue orders requiring its correction. The law does not authorize issuance of any order requiring cessation of pollution, but permits only orders "to use or to operate some practicable and reasonably available system or means which will reduce, control or eliminate pollution". While it might appear that pollution abatement would be facilitated if the Commission had authority to order immediate cessation of pollution, a long-range view of the problem shows this is not the case and that the present Connecticut law furnishes the wisest method of approach in that State. The Water Commission must first determine the nature of the specific problem, secondly devise a method of treating the particular waste, and finally require the offender to construct or install the equipment needed to treat the waste. For a municipality this might be a sewage-treatment plant, for a factory a chemical or mechanical device. The steps are time-consuming and expensive. The state is prepared to specify the particular method by which wastes may be treated, leaving the cost of installing the equipment the only obstacle. The Water Commission's program has been to first require municipalities to have a comprehensive engineering study made, the work planned then being divided into a series of units. Communities are then urged to take up the work required step-by-step.

10. PURPOSE OF WASTE TREATMENT. - Treatment of sanitary and industrial wastes has the nine-fold purpose of preventing the following: (1) pollution of waters intended for domestic use, (2) damage to private property, (3) damage to industry through pollution of waters needed for manufacturing processes, (4) infection of cattle by pollution of their water supply, (5) damage to commercial fisheries, especially contamination of shellfish, (6) annoyance due to offensive odors and fumes, (7) interference with recreational uses such as bathing, boating, camping, and fishing, (8) contamination of and aesthetic damage to water supplies, and (9) interference with navigation by filling in channels with waste deposits.

11. DOMESTIC SEWAGE. - Pollution abatement through treatment of domestic sewage has made rapid advancement during recent years in the Connecticut River Watershed. Estimates of the population served by complete and partial treatment, and those served by sewer systems without treatment plants reveal the improvement trend. Plate No. 13, a map showing the locations of "Sewerage Systems and Sewage-Treatment Plants" in the Connecticut River Watershed follows this section of the Appendix. Table XX, following, includes figures for 1936 and 1940. The table also contains estimates for plants proposed or under construction.

(Table on following page)

TABLE XX

ESTIMATED POPULATION OF CONNECTICUT RIVER WATERSHED
SERVED BY ORGANIZED SEWERAGE SYSTEMS
AND TREATMENT PLANTS

Facilities	1936 Population	1936 Percent	1940 Population*	1940 Percent	Estimated condition as of 1944 Population*	Estimated condition as of 1944 Percent
Sewered with complete treatment	30,000	2.4	100,000	7.7	111,000	8.4
Sewered with partial treatment	125,000	9.9	370,000	28.6	580,000	44.1
Sewered with no treatment	680,000	53.6	untreated 822,000	63.7	untreated 625,000	47.5
Unsewered	432,000	34.1				
Total	1,267,000	100.0	1,292,000	100.0	1,316,000	100.0

* Populations based on annual increase of 1/2 of 1 percent since 1930 Federal Census. Increase was 12.3 percent from 1920 to 1930, but estimates indicate slowing down to 10 percent in next 25 years.

Despite population increases and augmented sewer construction, the amount of untreated wastes reaching waterways is decreasing. While there has been only one plant giving complete treatment, constructed in the 1936-1940 period at New Britain, Connecticut, the several partial-treatment plants installed are more efficient than those built in previous years. Among the cities and towns having treatment plants are Keene, New Hampshire, Winchendon, Gardner, and Amherst, Massachusetts, and Thompsonville, Rockville, Manchester, Hartford, and Middletown, Connecticut. These plants, their processes, and the resulting effects are described in the paragraphs on stream conditions. In all cases, the operation of sewage-treatment plants is under the supervision of the health department of the state concerned. Periodic inspections are made and samples of untreated sewage and effluents are analyzed. Where the effluent is unsatisfactory according to health department standards, remedial measures can be enforced. Each plant is operated to give the maximum possible degree of purification from available equipment. The economic situation remains the ruling factor in any watershed improvement program, and funds available for installation of additional treatment equipment limit the quality of effluent. With sewage-disposal works under construction at Springfield, Holyoke remains the largest community to rely on dilution alone. While sewage dilution is an accepted means of disposal, a river may be compared to a septic tank, both being unsatisfactory methods of disposal when their rated capacities are exceeded. In the unsewered areas ordinarily the only possible stream pollution from outhouses, cesspools, or properly operated septic tanks is through seepage, but health authorities agree there is a definite health hazard in the use of rural sanitary facilities. Only in the northern part of the watershed is the use of these rural methods prevalent.

12. INDUSTRIAL WASTES.

a. Type of manufacturing. - In the Connecticut River Watershed, most industrial plants are located in the central and southern part of the basin between Greenfield, Massachusetts, and Middletown, Connecticut. Unlike other New England watersheds, there is a wide diversification of industry, both on the main stream and the tributaries. The sparsely populated zones of the upper valley are devoted chiefly to lumbering, dairying, and agricultural occupations. In the New Hampshire part of the basin, small concentrations of the textile and leather producing industries are situated along the Ashuelot, Sugar, and Mascoma Rivers. The Vermont section has slight industrial activity except at St. Johnsbury on the Passumpsic River, Springfield on the Black River, and Bellows Falls and Brattleboro on the main stream. In the Massachusetts area there are numerous industrial cities, with paper, textile, and metal products most important. The Millers, Chicopee, and lower Westfield Rivers are highly industrialized. In the Connecticut portion of the drainage basin machining predominates, with paper and textile manufacturing centers located on the Hockanum River. Electroplating on a large scale is done at numerous factories in Massachusetts and Connecticut. The greatest volume of industrial waste, about 40 million gallons daily, is discharged into the Connecticut River at Holyoke, but it is made up largely of inoffensive rinses from paper mills.

b. Character of industrial wastes. - Information as to the comparative concentrations of domestic sewage and the predominant trade wastes was obtained from data furnished by the Connecticut State Water Commission in their latest biennial report.[6] Table XXI, following, lists these wastes with their analyses:

TABLE XXI

ANALYSES OF SEWAGE AND TRADE WASTES

Parts per million

Type of waste	Suspended matter	Oxygen consumed	Biochemical oxygen demand	Reaction			Metals present
				pH	Acid	Alkali	
Sewage	250	240	260	7.0	0	5	iron 0.2
Brewery	5,000	15,000	5,000	6.8	trace	0	traces iron, copper, lead, tin.
Distillery	8,000	25,000	[illegible]	6.3	trace	0	traces iron, copper, lead, tin.
Laundry	700	800	1,000	9.0	0	5	none
Paper	300	1,000	700	7.2	0	0	"
Woolen	500	1,000	1,000	8.0	0	5	"
Cotton	600	800	700	7.0	0	2	"
Silk	1,000	1,200	1,000	7.3	0	0	"
Rayon	1,200	780	[illegible]	6.8	0	0	"
Steel pickle, strong	200	0	0	1.0	30,000	0	iron 14,000, copper 10, zinc 10.
Steel pickle, rinse	50	0	0	4.0	500	0	iron [illegible], copper 1, zinc 1.
Dairy	3,000	1,500	2,800	5.0	-	-	none

On a basis of the oxygen demand, it may be shown that certain industrial wastes are much stronger than sewage, distillery waste being almost sixty times as strong. Laundry wastes, emanating from all cities are objectionable mainly because of the turbidity they impart to treatment plant effluents. Steel pickling, the immersion of metal in acids to remove scale, creates strongly acidic wastes detrimental to bacteriological action. The wastes from electroplating solutions and rinses, while inorganic, are high in metallic content and harmful to marine life.

c. Treatment of industrial wastes. - Much research on the treatment of industrial wastes has been undertaken by state agencies. Studies are conducted to determine the effect of trade wastes on the design and operation of new sewage-disposal projects, so that decisions can be made as to which wastes can be included in the sanitary sewage and which should be separately treated. Many paper mills in the basin have installed "save-alls", screens and settling tanks to retrieve pulp and lessen the pollution nuisance, but in some cases these have been removed or by-passed because expected economies have not resulted. Among the methods used for treatment of ferrous wastes are the neutralization of acid and precipitation of iron by alkaline reagents, and the production of copperas. No useful by-products have been obtained economically through the treatment of textile wastes, but such treatment is often necessary to prevent clogging of municipal filtration beds. Methods of treating textile wastes prior to their discharge into streams are described in a paper of the American Institute of Chemical Engineers.[7]

d. Economics of industrial waste treatment. - Satisfactory treatment of all industrial wastes at a reasonable cost to the plant owner is at present not possible. A manufacturer should, however, realize his responsibility to the public in preventing indiscriminate waterway pollution. While there generally is willingness on the part of the manufacturer to cooperate in pollution abatement, the prospect of a substantial expenditure with a recurring permanent addition to operating costs, necessitated by the operation of waste treatment equipment, is a strong deterrent. In the larger cities having municipal treatment plants sufficiently dilute industrial wastes may be accommodated. If, however, a certain industrial plant discharged a large volume of wastes, it would be uneconomical to treat it at a municipal plant and it might be best included in the storm sewers. In Connecticut, several industrial plants are operating waste treatment units, which may be justified on the basis of comparative costs of treating the wastes at municipal plants and economies effected through waste recovery and by-product production.

13. REFUSE DISPOSAL. - Several rubbish dumping grounds are situated along stream banks below high-water levels. While not major sources of pollution, any steps to effect a general improvement of waterways should consider them. There are no municipal garbage or refuse incineration plants in the watershed. While numerous refuse dumping grounds are situated along the rivers at industrial plants, and some promiscuous deposition of waste occurs in the various cities, the main river is not subject to such gross contamination as certain of the tributaries.

14. WATER ANALYSES. - The quality of the waters of the Connecticut River Basin is best indicated by the analytical results derived from sampling programs maintained by public agencies. In New Hampshire and Vermont data have been collected giving types and amounts of wastes discharged, stream conditions, and the present status of sewage treatment at some of the cities and towns. These data are presented in Paragraph 16 of this section. The Work Projects Administration, under the sponsorship of the Massachusetts Department of Public Health, has carried on pollution studies, results of which are given in accompanying paragraphs. In the Millers River Watershed, eighteen stations were selected, twelve on the Millers River and the remaining six along three important tributaries, Orcutt Brook, Mill Creek, and Otter River. Samples were taken during the period June 1 to July 8, 1937, and analyses made. On the Connecticut River twenty-two stations were selected, ten on the main stream and the remaining twelve along important Massachusetts tributaries. Samples were collected during the period September 1 to October 20, 1937, and analyzed. In Connecticut, catch samples are taken monthly by the State Water Commission at each stream gaging station, and tested at the Health Department laboratory. Dissolved oxygen is determined only in the low-flow months of July, August, and September.

a. Chemical constituents. - For proper understanding of the analyses given, brief statements relative to certain of the tests follow:

(1) Total solids represent the amount of organic and inorganic matter in suspension and in solution.

(2) Free ammonia in water indicates the presence of decomposing organic substances which may contain disease germs. High ammonia content shows recent pollution.

(3) Nitrites and nitrates are a measure of the progress of oxidation. When the values are high it means that purification is taking place or has occurred.

(4) Chlorides are a measure of the domestic or industrial wastes in river waters. They do not, however, measure the length of time since pollution.

(5) Alkalinity is a measure of the carbonate, bicarbonate, and hydroxide content of the water expressed as parts per million in terms of calcium carbonate.

(6) Hydrogen-ion concentration is a measure of the acidity or alkalinity of the water, and is generally expressed as the "pH", the logarithm of the reciprocal of the hydrogen-ion concentration. A pH of 7 indicates a neutral solution, greater values are alkaline and lesser values acid.

(7) Biochemical oxygen demand is a measure of the oxygen required to stabilize the decomposable organic matter by bacterial action. It is generally expressed as the oxygen, in parts per million, that is used up in 5 days at 20 degrees Centigrade. Objectionable conditions arise when the demand exceeds the oxygen available in the stream.

(8) Dissolved oxygen is a ratio of the oxygen in solution to the amount which could be in solution if saturated at a given temperature. It is generally expressed as the percent saturation. Sanitary engineers are generally agreed that objectionable conditions are most likely to occur when the dissolved oxygen content is less than 50 percent and that values below 25 percent indicate exceedingly bad conditions.

b. Connecticut River in New Hampshire and Vermont. - There are no chemical analyses available for this portion of the Connecticut River Basin. In general the mean flows afford enough dilution to prevent offensive conditions but nuisances are evident at some points of discharge during periods of low flow.

c. Connecticut River Watershed in Massachusetts. - Averages have been computed for several of the analyses made by the Massachusetts Department of Public Health's Pollution Studies. These figures do not necessarily indicate the most critical conditions but do show average conditions for the periods during which the tests were made. Sampling on the Millers River stations covered four 24-hour periods during the months of June and July 1937. Each sample represents a one-gallon composite collected over the duration of the run by taking equal portions at half-hour intervals. Dissolved oxygen samples were taken four times daily. The oxygen was fixed in the field and the samples sent to the laboratory for titration. During September and October 1937, samples were taken at the other stations in the Connecticut River Basin using a similar procedure. Table XXII lists the results of analyses on the Millers River and tributaries while Table XXIII lists the results of analyses for the remainder of the basin.

(Table XXII on following page)

TABLE XXII

WATER ANALYSES - MILLERS RIVER WATERSHED - 1937

Station	Total solids, p.p.m.	Free ammonia, p.p.m.	Nitrites and nitrates, p.p.m.	Chlorides, p.p.m.	Biochemical oxygen demand, p.p.m.	Alkalinity, p.p.m.	Dissolved oxygen, per-cent saturation
Millers River at Winchendon Springs	49	.014	.070	6.0	2.1	4.8	71.4
Millers River at Winchendon	52	.018	.072	4.4	1.3	4.5	79.8
Millers River at Waterville	52	.018	.087	3.8	1.1	4.0	77.8
Otter River at South Gardner	73	.030	.458	4.3	1.8	4.0	74.8
Otter River at Templeton (Mi. 5.4)	84	.326	.248	5.5	2.0	10.5	71.3
Otter River at Templeton (Mi. 4.7)	77	.218	.518	5.6	2.3	8.7	74.2
Otter River at mouth	82	.234	.219	5.2	2.0	9.2	69.9
Millers River at So. Royalston (Mi. 25.9)	63	.062	.256	4.6	0.8	4.2	67.6
Millers River at So. Royalston (Mi. 25.7)	66	.050	.354	4.9	1.2	5.5	71.3
Millers River at Athol (Mi. 19.9)	56	.014	.145	4.9	2.6	6.2	82.6
Mill Creek at Athol	54	.022	.149	5.7	1.9	10.8	82.6
Millers River at Daniel Shea Bridge, Athol	54	.044	.091	4.6	2.3	5.1	81.6
Millers River at West Orange	57	.058	.128	4.9	2.0	7.0	74.8
Orcutt Brook at mouth	53	.008	.108	4.8	2.0	6.5	84.4
Millers River at Erving (Mi. 8.8)	59	.044	.104	4.4	1.3	7.7	75.8
Millers River at Erving (Mi. 8.2)	55	.044	.128	3.8	1.6	7.0	84.6
Millers River at Millers Falls	61	.026	.083	4.0	2.5	6.5	82.8
Millers River at Gill	61	.018	.136	5.0	2.1	5.0	85.0

Figures given in Table XXII show that there are several pollution sources on the Millers River. The biochemical oxygen demand (B.O.D.) decreases from Winchendon Springs to Waterville, indicating that self-purification is taking place. Although Otter River contributes some pollution, there is sufficient recovery before the stream reaches South Royalston. The next appreciable source of pollution is at Athol but, continuing downstream, results reveal further self-purification to Millers Falls. Here a rise in the B.O.D. shows the introduction of more wastes. The dissolved oxygen, although somewhat depleted at South Royalston due to inflow from the Otter River, is not so low as to promote offensive conditions. The chloride content is not excessive but pollution at some points is indicated by fluctuating values having the same trend as the B.O.D. The total solids show slight increases, with highest values occurring in the Otter River. The Millers River at the mouth is in about the same sanitary condition as at the headwaters. The ample supply of oxygen permits sufficient self-recovery in the uninhabited reaches to care for the wastes entering at population centers.

(Table XXIII on following page)

TABLE XXIII

WATER ANALYSES - CONNECTICUT RIVER WATERSHED IN MASSACHUSETTS - 1937

Station	Total solids, p.p.m.	Free ammonia, p.p.m.	Nitrites and nitrates, p.p.m.	Chlorides, p.p.m.	Biochemical oxygen demand, p.p.m.	Alkalinity, p.p.m.	Hydrogen-ion concentration, pH	Dissolved oxygen, percent saturation
Connecticut River at East Northfield	86	.020	.146	4.6	1.0	39	7.3	85.4
Millers River below Millers Falls	56	.030	.164	3.8	3.2	10	6.8	86.3
Connecticut River at mouth of Deerfield R.	108	.026	.092	4.0	1.3	20	6.8	94.6
Connecticut River at Sunderland	123	.062	.118	4.0	2.4	35	7.2	76.1
Connecticut River above Northampton	75	.050	.093	4.2	1.2	28	7.2	92.2
Mill River at Northampton	78	.042	.144	4.0	2.8	22	7.0	94.5
Mill River at mouth	148	.772	.069	6.0	11.3	31	6.5	56.6
Manhan River above Easthampton treatment plant	156	.035	.044	8.4	5.6	28	6.8	76.2
Manhan River below Easthampton treatment plant	148	.034	.058	9.2	10.2	32	7.0	75.8
Connecticut River above Holyoke	114	.034	.112	5.4	1.9	28	7.2	80.5
Connecticut River below Holyoke	106	.026	.102	4.8	1.8	28	7.1	89.2
Chicopee River at Chicopee Falls	70	.094	.187	4.2	1.3	12	6.6	73.7
Chicopee River at mouth	80	.084	.224	4.4	1.5	10	6.6	71.4
Conn. River at Chicopee-Springfield line	103	.099	.183	6.0	2.2	27	6.9	69.8
Connecticut River at West Springfield-Agawam line	80	.042	.170	4.3	2.2	26	7.0	80.9
Westfield River above Westfield	60	.068	.084	2.6	1.6	17	7.0	93.8
Westfield River below Westfield	68	.036	.092	3.2	1.9	15	6.9	94.8
Westfield River below Agawam Bridge	69	.054	.153	3.2	1.8	23	6.9	87.8
Conn. River at Conn. state line-East shore	101	.135	.186	4.7	1.5	31	6.9	71.2
Conn. River at Conn. state line-West shore	104	.060	.141	4.7	3.1	33	7.0	71.0

The analyses show that the condition of the Connecticut River, as it reaches Massachusetts, is not objectionable but there is evidence of pollution as the stream flows through the state. The total solids show an increase to Sunderland, and a decrease above Northampton, but considerable pollution from the Mill and Manhan Rivers causes an increase below the town. There is no marked change in the solids content from Holyoke to the Connecticut state line. The free ammonia tests have the same trend and indicate excessive pollution from the lower Mill River. That self-purification is taking place, however, is shown by the high nitrite and nitrate content. The chloride content is not high but fluctuations show the influx of polluting substances at various points. The biochemical oxygen demand shows that putrescible organic matter enters the river above Sunderland but some purification takes place down to Northampton. The Mill and Manhan Rivers, in themselves, are badly polluted and have a marked effect on the condition of the main stream. From Holyoke to Springfield, some self-purification is evident but the discharge of wastes from Springfield and vicinity show pollution downstream to the state line. Depletion of dissolved oxygen at various points bears out the conclusions drawn from the biochemical oxygen demand analyses.

d. Connecticut River Watershed in Connecticut. - Analytical results, given in Table XXIV, were obtained from the State Water Commission for one main-stream and six tributary stations. No other analyses were available to show the condition of the Connecticut River as it flows through the state.

(Table on following page)

TABLE XXIV

WATER ANALYSES - CONNECTICUT RIVER WATERSHED IN CONNECTICUT

Station and date of sample	Suspended solids, p.p.m.	Hydrogen-ion concentration, pH	Chlorides, p.p.m.	Alkalinity, p.p.m.	Biochemical oxygen demand p.p.m.	Dissolved oxygen, percent saturation
Connecticut River at Thompsonville						
10- 3-38	24.0	6.9	1.0	23	0.7	-
11-28-38	5.2	6.9	3.2	25	1.7	-
12-13-38	65.0	6.7	0.6	16	0.9	-
1- 9-39	5.2	6.9	1.2	26	1.0	-
2- 9-39	4.8	6.9	2.2	28	2.3	-
3- 6-39	9.4	6.9	1.6	20	0.9	-
4- 6-39	21.0	6.9	1.2	20	1.1	-
5- 4-39	30.0	7.1	0.3	16	0.4	-
6- 7-39	4.0	7.1	1.6	24	1.7	-
7-12-39	3.0	6.9	3.2	33	2.3	54.9
8-10-39	6.2	6.7	2.6	27	1.9	65.0
9-13-39	4.6	6.7	5.2	30	1.6	57.7
10- 5-39	7.4	7.1	3.6	42	1.3	-
Scantic River at Broad Brook						
10- 3-38	8.0	6.7	6.4	19	0.8	-
11-30-38	6.2	6.9	4.6	25	1.2	-
12-13-38	5.0	6.7	2.6	13	1.4	-
1- 9-39	5.2	6.9	3.2	13	1.0	-
2- 2-39	2.6	6.9	4.2	24	1.4	-
3- 6-39	37.	6.9	2.8	17	1.0	-
4- 6-39	7.0	6.9	1.6	14	0.9	-
5- 4-39	5.4	7.1	2.0	21	0.4	-
6- 7-39	11.	7.1	3.6	33	2.2	-
7-12-39	19.	6.9	4.6	32	1.9	81.9
8-10-39	6.4	7.2	6.0	35	1.1	81.8
9-13-39	5.2	7.1	5.2	31	2.2	90.7
10- 5-39	4.2	7.1	3.6	32	2.1	-
West Branch Farmington River at New Hartford						
10- 4-38	5.4	6.9	0.8	14	0.5	-
11-29-38	4.4	6.9	2.4	13	0.8	-
12-15-38	4.4	6.7	0.8	11	0.4	-
1-10-39	5.0	6.9	0.8	10	0.4	-
2-14-39	3.6	6.9	1.6	11	1.0	-
3-16-39	3.6	6.9	1.0	9	0.9	-
4-11-39	4.0	6.9	1.0	11	0.4	-
5- 9-39	1.4	7.1	0.8	15	1.0	-
6-14-39	7.6	7.1	1.4	11	1.4	-
7-13-39	3.6	6.7	1.2	12	0.9	100.0
8-17-39	4.4	7.1	2.6	17	1.1	104.8
9-18-39	2.6	6.9	1.8	12	0.9	93.7
10-16-39	1.2	7.1	1.2	13	0.7	-

(Table continued on following page)

TABLE XXIV (Cont'd)

WATER ANALYSES - CONNECTICUT RIVER WATERSHED IN CONNECTICUT

Station and date of sample	Suspended solids, p.p.m.	Hydrogen-ion concentration pH	Chlorides, p.p.m.	Alkalinity, p.p.m.	Biochemical oxygen demand p.p.m.	Dissolved oxygen, per cent saturation
East Branch Farmington River at New Hartford						
10- 4-38	9.2	6.5	0.8	6	0.7	-
11-29-38	1.8	6.7	1.6	10	0.2	-
12-15-38	17.	6.9	1.4	10	0.7	-
1-10-39	4.0	6.5	1.2	8	0.8	-
2-14-39	2.0	6.5	1.4	8	0.4	-
3-16-39	1.8	6.5	1.4	11	0.2	-
4-11-39	6.8	6.9	0.8	7	0.4	-
5- 9-39	1.2	6.9	1.0	7	0.4	-
6-14-39	4.8	7.1	1.6	9	0.6	-
7-13-39	11.	6.5	0.6	8	0.6	91.0
8-17-39	36.	5.9	1.8	11	0.5	79.9
9-18-39	14.	6.9	1.4	13	1.5	97.9
10-16-39	5.8	6.9	1.6	14	1.5	-
Farmington River at Tariffville						
9- 1-38	1.2	7.1	3.6	17	0.4	98.9
10- 3-38	8.4	6.7	1.6	12	0.7	-
11-29-38	5.8	6.9	2.2	16	1.0	-
12-15-38	2.0	6.7	1.6	12	0.6	-
1- 9-39	1.2	6.7	1.0	12	0.8	-
2- 9-39	2.0	6.7	2.0	13	0.7	-
3- 6-39	6.6	6.9	1.2	12	0.6	-
4- 6-39	2.4	6.7	1.8	9	0.8	-
5- 4-39	4.2	7.1	2.0	12	0.7	-
6- 7-39	2.0	6.9	1.8	20	1.3	-
7-12-39	1.4	6.9	2.8	18	1.4	92.7
8-10-39	2.3	7.0	1.6	18	1.2	89.1
9-13-39	2.6	7.1	2.8	13	1.2	97.9
Hockanum River at East Hartford						
10-20-38	16.	6.7	5.6	30	6.2	-
11- 3-38	8.8	6.7	7.6	31	3.9	-
12-13-38	3.4	6.5	3.4	14	3.0	-
1- 5-39	5.0	6.5	5.6	25	9.9	-
2- 2-39	9.2	6.3	5.6	23	10.	-
3-20-39	4.6	6.7	3.6	18	3.3	-
4-27-39	5.8	6.5	4.4	23	2.4	-
5-18-39	16.	6.7	5.8	33	6.1	-
6- 8-39	9.6	6.7	5.8	37	4.6	-
7- 6-39	19.	6.9	6.4	38	8.3	84.3
8-24-39	5.8	6.7	8.8	41	1.8	74.5
9-27-39	13.	6.7	12.	46	8.4	29.9
10-19-39	5.8	6.9	11.	46	10.	-

(Table continued on following page)

TABLE XXIV (Cont'd)

WATER ANALYSES - CONNECTICUT RIVER WATERSHED IN CONNECTICUT

Station and date of sample	Suspended solids, p.p.m.	Hydrogen-ion concentration, pH	Chlorides, p.p.m.	Alkalinity, p.p.m.	Biochemical oxygen demand, p.p.m	Dissolved oxygen, per cent saturation.
Salmon River at Leesville						
10-15-38	9.4	6.9	4.2	15	1.2	-
11-16-38	5.8	6.7	3.0	11	0.7	-
12-22-38	4.8	6.7	2.6	7	0.3	-
2 -20-39	6.0	6.9	2.4	7	0.5	-
3 -20-39	8.8	6.9	2.4	7	0.3	-
4 -20-39	5.4	6.7	2.0	7	0.4	-
5 -16-39	1.4	7.1	2.2	10	0.7	-
6 -19-39	7.2	6.9	2.2	14	0.6	-
7 -18-39	2.0	6.3	4.0	9	0.8	97.6
8 -22-39	4.6	6.7	3.2	12	0.9	81.7
9 -26-39	3.2	7.1	4.4	13	0.6	87.6
10- 9-39	2.4	6.9	3.0	12	0.8	-

The Connecticut River at Thompsonville appears to be in good sanitary condition. The dissolved-oxygen content, lowest during the drier seasons, is not so low as to promote offensive conditions. The biochemical oxygen demand (B.O.D.) is also low, indicating the absence of any large amount of organic matter. Although there are intermittent increases in suspended solids, the low B.O.D. shows that these solids are not of an organic nature. The pH is generally slightly on the acid side. The analyses of the Scantic River at Broad Brook indicate little contamination. As at Thompsonville, the fluctuations in the suspended solids are probably not due to organic matter but to an influx of inorganic trade wastes. The Farmington River shows a low oxygen demand and a high oxygen saturation value, indicating good condition. As for the Hockanum River, the suspended solids content fluctuates considerably, the high B.O.D. indicating that this is due to putrescible organic matter. The chloride analyses further substantiate this. The water is acid, pH values varying from 6.3 to 6.9. Dissolved oxygen content is low at times, reaching a minimum value of 29.9 percent. The Salmon River results indicate that the stream is in a satisfactory condition and that pollution is slight. There is an ample supply of oxygen and the demand is less than 1 part per million in all cases except one. Suspended solids and chlorides are low. The water is generally acid, the pH running between 6.3 and 7.1. The results in Table XXIV indicate that the Hockanum River is the only grossly polluted Connecticut stream in the Connecticut River watershed.

15. SANITARY CONDITIONS ALONG STREAMS OF THE CONNECTICUT RIVER WATERSHED. - The following pages picture sanitary conditions as described in recent reports and in unpublished data made available by other agencies. Although discussion in downstream order best presents the cumulative picture, some departure was advisable in the case of the Connecticut River Watershed because of its pennate stream pattern. For each state the important tributaries are described in downstream order, followed by a description of the main stream. Pollution problems and existing treatment plants in the drainage basins for which data were available are described in the paragraphs listed below:

Drainage basin	Paragraph
Connecticut River in New Hampshire and Vermont	16
Millers River	17
Deerfield River	18
Chicopee River	19
Swift River	
Ware River	
Quaboag River	
Westfield River	20
Connecticut River in Massachusetts	21
Farmington River	22
Connecticut River in Connecticut	23
Scantic River	
Hockanum River	

16. CONNECTICUT RIVER WATERSHED IN NEW HAMPSHIRE AND VERMONT. - In New Hampshire there is little pollution north of the Ammonoosuc River. Studies of pollution on the latter stream,[8] made in 1932, showed that there was high contamination in portions of the river above Bethlehem. This was due principally to the hotels discharging raw sewage. Conditions are at their worst during the summer months when the population is largest and the flows are lowest. The other main tributaries in New Hampshire are the Mascoma, Sugar, and Ashuelot Rivers. Raw sewage, septic tank effluent, and textile wastes are discharged into the Mascoma

River at Enfield and Lebanon. Conditions on the river and on Mascoma Lake are unsatisfactory but these bodies of water may still be used for recreational purposes. The Sugar River receives both domestic and industrial wastes chiefly from Sunapee, Newport, and Claremont. The two latter towns have sewerage systems discharging into the river. Need of partial treatment during periods of low flow is indicated. The Ashuelot River is comparatively clean in its upper reaches but a concentration of population and industry creates pollution problems in the lower reaches. Keene, the largest New Hampshire community in the basin, treats its domestic sewage in Imhoff tanks but many industrial plants discharge untreated wastes into the river, giving rise to nuisances. The portion of the watershed in Vermont is relatively clean and the area will probably never present acute water-supply or pollution problems. There are, however, woolen, pulp and paper mills, and creameries which discharge their wastes into the main stream or its tributaries. The chief sources of contamination in Vermont are given below in Table XXV.

TABLE XXV

SANITARY STATISTICS

CONNECTICUT RIVER BASIN IN VERMONT[3]

Town or Village	Domestic wastes, gallons per day	Industrial Wastes		River into which discharged
		Type	Quantity, gallons per day	
Lunenberg		Paper pulp	1,000,000	Connecticut
Lyndonville		Creamery	80,000	Passumpsic
St. Johnsbury	600,000			Passumpsic
McIndoes		Creamery	5,000	Connecticut
Newbury		Paper pulp	625,000	Connecticut
Hartford		Wool	400,000	White
White River Jct.	200,000			Connecticut
Quechee		Wool	67,500	Ottauquechee
Windsor	300,000			Connecticut
Ludlow		Wool	8,000	Black
Springfield	400,000			Black
Bellows Falls	300,000	Creamery	87,000	Connecticut
Brattleboro	900,000	Creamery	12,000	Connecticut

17. MILLERS RIVER. - The Millers River Watershed is sparsely settled, although there are population concentrations at Gardner, Winchendon, Athol, and Orange. The total population in the basin, according to 1935 state census figures, is about 46,000. Chemical analyses, given in Paragraph 14 of this section, indicate the degree of pollution on the Millers River and its tributaries, Otter River and Orcutt Brook. The principal sources of industrial pollution are given below in Table XXVI.

TABLE XXVI

INDUSTRIAL WASTES IN THE

MILLERS RIVER BASIN[9]

City or town	River	Type	Quantity, gallons per day
Winchendon	Millers	Cotton, dye	75,000
Templeton	Otter	Paper	176,000
Athol	Millers	Laundry, dye	311,000
Orange	Millers	Acid, oil, and grease solutions	3,400
Erving	Millers	Paper	1,350,000

Following, in downstream order, is a description of sanitary conditions at the principal points of pollution in the Millers River Basin:

Winchendon. - At Winchendon a municipal sewerage system and treatment plant serves about 50 percent of the population. The wastes are treated by sedimentation and sand filtration before being discharged into the Millers River. The plant operates satisfactorily according to the Department of Public Health. Twelve private outlets, from 4 to 18 inches in size, discharge raw sewage into the stream. Four industrial plants contribute cotton rinse and dye wastes along with the untreated sanitary wastes of about 475 employees.

Gardner. - Gardner maintains a municipal sewerage system and two disposal plants, one at South Gardner and the other at East Templeton. These treat about 1,000,000 gallons daily. Soap, caustic, acid, and bleach wastes, totaling about 182,500 gallons per day, are discharged into the municipal sewerage system. At present the plants are appreciably overloaded and the State Department of Public Health has recommended that more adequate treatment works be provided.

Templeton. - In the Baldwinville section 14 private outlets, from 4 to 18 inches in size, discharge into the Otter River, creating a nuisance. Six manufacturing plants contribute paper machine, fiber, beater and washing, and sanitary wastes, untreated, to the river.

Athol. - A municipal sewerage system, serving about 75 percent of the population, discharges into the Millers River through five outfalls ranging from 8 to 16 inches in size. Twelve private outlets discharge domestic and industrial wastes, untreated, into the stream or the adjacent industrial canal.

Orange. - At Orange untreated domestic and industrial wastes are discharged directly into the Millers River through two 18-inch tile outlets from the municipal sewerage system and through nine private outlets. Industrial wastes consist of acids, oil and grease solutions, and waste water from processing of castings.

Erving. - A municipal sewerage system and two private outlets discharge domestic sewage into the Millers River at Erving. Four manufacturing plants also discharge rag washing, paper machine wastes, and plating liquors into the stream.

Investigations in 1938 by the state health department showed objectionable conditions on the banks near some of the sewer outlets at Templeton, Athol, Orange, and Erving, but the water did not appear to have reached the nuisance stage.

18. DEERFIELD RIVER. - In Vermont the Deerfield River is in good condition. A minor amount of domestic pollution enters the stream at Wilmington, Whitingham, and Readsboro, but this does not produce any appreciable downstream effect. The entire watershed is sparsely settled and contains few industrial plants. The waters in the Massachusetts portion of the basin are in good condition except for the lower reaches, which are polluted from mixed wastes discharged mainly at Deerfield and Greenfield. Sanitary conditions at the principal sources of contamination, in downstream order, are as follows:

Monroe. - Several pipes, ranging from 3 to 12 inches in size, discharge raw sewage either directly into the Deerfield River or at distances up to 125 feet from the water's edge. The condition of the banks, especially during the warm summer months, is obnoxious and unsanitary. About 192,000 gallons of paper wastes are discharged daily.

Rowe. - Three outlets discharge raw sewage into the stream at Rowe. The pollution here is chiefly industrial, consisting of about 96,000 gallons per day of pulp and bleaching wastes, which have been detrimental to fish life.

Colrain. - There is no municipal sewerage system in the town, but several sewers, of 3- to 10-inch diameter, discharge into the river or on the banks at distances up to about 50 feet. Objectionable conditions have arisen near the outlets, although the effect on the stream itself is not noticeable to any extent. About 15,500 gallons of bleachery wastes are discharged into the river daily.

Shelburne. - The domestic wastes are emptied into the Deerfield River through several private outlets, mostly at Shelburne Falls. Two outlets from the town sewerage system, serving 800 people, also empty into the river. The stream receives about 8000 gallons of industrial wastes daily.

Deerfield. - The village of Old Deerfield is served by a sewerage system accommodating about 200, discharging into the Deerfield River through an outfall sewer. Deerfield Academy, with an enrollment of 600, has a private outlet near the village sewer. A large portion of the town's population is in South Deerfield which drains into the Connecticut River.

Greenfield. - A municipal sewerage system, serving about 75 percent of the population, discharges into the Deerfield River and one of its tributaries, the Green River. The industrial wastes of the town are mostly discharged into the public sewer. The town is now constructing, at a cost of $92,000, a plant for the treatment of all sewage and industrial wastes. This plant, designed to serve about 20,000 people, will have a daily capacity of 2,000,000 gallons. Treatment will consist of screening, comminution, and sedimentation in covered mechanically-cleaned settling tanks. The effluent is to be discharged into the Green River. A fixed-roof tank, with a capacity of 2.0 cubic feet per capita, is to be provided for digestion and an open tank of the same capacity is to be used for storage. The digested sludge, after drying on covered beds having a capacity of 0.75 square foot per capita, will be used as fill. In order to connect the plant to the present sewerage system, construction of an interceptor at a cost of $12,800 is underway.

19. CHICOPEE RIVER. - The Chicopee River is formed by the confluence of the Swift, Ware, and Quaboag Rivers in the Three Rivers section of Palmer, Massachusetts. The total population within the basin in 1935 was estimated to be about 110,000. The Ware River above Coldbrook and the Swift River above Winsor Dam are preempted for water-supply uses and are under strict supervision by the Metropolitan District Water Supply Commission. These portions of the basin are uncontaminated. Regarding

conditions in other parts of the watershed, Massachusetts House Document No. 2050[9] states,

> "The results of the analyses . . . show considerable evidence of pollution of the Quaboag River below Palmer and of the Ware River below South Barre, but the evidence of pollution in the Ware River largely disappears before this stream reaches its confluence with the Swift River. There is visible evidence of pollution from time to time, particularly by industrial wastes in Monson or Chicopee Brook below the thickly settled parts of Monson, and there is some evidence of industrial waste pollution in the Quaboag River as it passes through Warren, and considerable evidence in Palmer. As a whole, however, the (Chicopee) river and its tributaries are not in a seriously polluted condition excepting along the banks, where the sewage is not readily removed by the ordinary flow . . . the effect of the discharge of sewage from the town of Ware is noticeable in the samples collected at Gibbs Crossing a short distance below the town."

Table XXVII, following, shows the principal sources of industrial pollution.

TABLE XXVII

INDUSTRIAL WASTES IN THE CHICOPEE RIVER BASIN[9]

City or town	River	Type	Quantity, gallons per day	
			To river	To sewer
Barre	Ware	Rinse, dye	132,700	
Hardwick	Ware	Paper stock, beater	36,000	
Ware	Ware	Wool, paper	80,000	6,000
E. Brookfield	Quaboag	Felt	131,000	
Brookfield	Quaboag	Glue, wash water	13,000	
W. Brookfield	Quaboag	Wash water	8,000	
Warren	Quaboag	Wash, dye, print	62,200	
Monson	Quaboag	Wool, dye	147,500	
Palmer	Swift	Wash, bleach, dye	300,000	
Palmer	Ware	Wash	63,000	
Palmer	Quaboag	Wash, soaps, acid	600,000	
Ludlow	Chicopee	Wash, dye		108,000
Wilbraham	Chicopee	Wash, paper	1,125,000	
Springfield	Chicopee	Wash, dye, chemical	3,753,000	330,000
Chicopee	Chicopee	Acid, dye, wash, cooling	2,002,400	11,300

The towns of Barre, East Brookfield, Brookfield, West Brookfield, Warren, and Monson have no municipal sewerage systems. The latter two dispose of their domestic wastes through several private outlets into the Quaboag River while the other towns use rural facilities. Raw domestic sewage is contributed by municipal sewers at Hardwick, Belchertown, Ware, North Brookfield, and Palmer. At Spencer there is a sewerage system with treatment works, built in 1897 and enlarged in 1935. Treatment is by sand filtration and generally gives a satisfactory degree of purification. At the Monson State Hospital, which has an average population of 1900 persons, works, ample for future increases, have been provided for the treatment of sewage. The Town of Ludlow has a combined sewerage system which receives both industrial and domestic wastes. A pumping station, intercepting sewers, and a treatment plant designed to serve 7000 people and having a daily capacity of 900,000 gallons, are being built at a cost of $96,500. Treatment will consist of screening, grit removal, pre-aeration, settling, sludge digestion, sludge drying, and chlorination of effluent. Chicopee has a municipal system for the domestic wastes and a small portion of the industrial wastes (see Table XXVII). None of the wastes are given treatment. About 10 percent of Springfield's population resides within the Chicopee River Watershed. Domestic sewage in this portion of the city enters the municipal sewerage system but industrial wastes are discharged into the river. Further discussion of conditions in Chicopee and Springfield is given in Paragraph 21.

20. WESTFIELD RIVER. - The estimated population within the drainage area, based on 1935 state census figures, is 39,000. In the Westfield River Basin there are several sources of pollution, both industrial and domestic. Table XXVIII summarizes the principal sources of industrial pollution.

(Table on following page)

TABLE XXVIII

INDUSTRIAL WASTES IN THE WESTFIELD RIVER BASIN[9]

City or town	River	Type	Quantity, gallons per day	
			To river	To sewer
Becket	West Branch	Paper, beater	774,000	
Chester	West and Middle Branches	Ore washing	18,000	
Huntington	West, Middle, and East Branches	Woolen	40,000	
Russell	Little and Westfield	Paper, rag	2,338,000	
Westfield	Little and Westfield	Paper, metal, plating	701,500	73,000
W. Springfield	Westfield	Paper, rag	2,080,000	
Agawam	Westfield	Paper, rag	881,800	

Massachusetts House Document No. 2050[9] states,

> ". . . some of these industrial wastes have affected fish life, and in any program for improving the condition of the Westfield River steps should be taken to discharge the foul industrial wastes into the municipal sewerage system, or to treat these wastes at their source. While there have been some complaints relative to the pollution of the Westfield River, conditions have not yet been reached which should require legislation for the purpose of preventing further pollution. However, in view of the improvements now under way for improving . . . (other) rivers in this region, consideration should be given to the removal and treatment of the sewage of the city of Westfield and the towns of Chester, Huntington, West Springfield and Agawam."

The chief sources of domestic pollution in the Westfield Basin are numerous outfalls at Chester, Russell, Granville, Westfield, West Springfield, and Huntington. The latter three, with Agawam and Plainfield, are the only municipalities having public sewerage systems. The only treatment plant in the basin is that at the Westfield State Sanatorium operated by the Department of Public Health. In many of the communities sewers originally intended for draining surface water are being used for the removal of domestic wastes. Agawam has allowed the City of Springfield to locate a treatment plant in the town without payment of taxes on the site. In return, Springfield has agreed to treat all sewage from Agawam. It will be necessary to construct interceptors connecting present outfalls to the new treatment works. Pollution from other parts of the watershed is negligible, disposal of wastes generally being by rural means.

21. CONNECTICUT RIVER IN MASSACHUSETTS. - The drainage area of the Connecticut River proper in Massachusetts includes all or part of 20 municipalities. As shown by the analyses in Paragraph 14c the condition of the river as it reaches Massachusetts is unobjectionable but considerable polluting matter, both domestic and industrial, is discharged into the stream before it enters Connecticut. Table XXIX summarizes the principal points of industrial pollution.

TABLE XXIX

INDUSTRIAL WASTES DISCHARGED INTO CONNECTICUT RIVER IN MASSACHUSETTS[10]

City or town	Type	Quantity, gallons per day	
		To river	To sewer
Montague	Paper, caustic, acid, laundry	3,870,400	
Greenfield	Dye, acid, plating, laundry	100	95,300
Northampton	Sulfite paper	2,750,000	
Easthampton	Textile	9,200	
South Hadley	Paper	2,402,000	
Holyoke	Paper, textile, laundry	39,801,000*	8,000
Chicopee	Dye, acid, brewery	130,000	65,000
Springfield	Boiler, dye, chemical		1,780,000
Agawam	Paper, woolen, dye, soap	882,000	10,000

*Consists mostly of inoffensive rinse waters.

The continued discharge of raw industrial and domestic wastes into the stream has caused conditions which are both unsightly and a menace to public health. Massachusetts House Document No. 1735[10] states,

> "There has been much activity in recent years in opposition to the continued pollution of the Connecticut River, chiefly as a result of complaints from the authorities of the State of Connecticut and from the recreational interests. In this connection the Department (of Public Health) has found it necessary to advise against the use of the Connecticut for bathing in Agawam, Smith's Ferry, Holyoke and Hadley."

Investigations have been made and remedial measures begun in certain of the more seriously affected localities.[11] Following, in downstream order, are listed the principal sources of contamination with a summary of the sanitary conditions and present activity in the elimination of pollution:

Greenfield. - The densely populated portion of the town is served by a sewerage system emptying into the Deerfield River, discussed in Paragraph 18.

Deerfield. - Sanitary wastes enter the river through the town sewer, a small private outfall, and an outlet from the Boston and Maine Railroad yards in East Deerfield. Further discussion is given in Paragraph 18.

Montague. - A municipal sewerage system discharges raw domestic and industrial wastes through six outlets from 12 to 30 inches in size. In addition eight small pipes discharge raw sewage, and eleven outlets, 3 to 24 inches in size, discharge process waters, mostly from paper product factories. The majority of the outlets are situated in the Turners Falls section, creating a concentration of polluting wastes in a relatively short reach of the river. The Department of Public Health has recommended such remedial measures as construction of intercepting sewers and treatment works but no action has yet been taken.

Amherst. - This town has no industries, being noted chiefly for its two colleges. An intermittent sand filter plant treats about 20 percent of the daily sewage flow, the remaining 80 percent being discharged by the municipal sewerage system into a small Connecticut River tributary. A treatment plant, designed to serve 8000 people and having a capacity of 1,000,000 gallons daily, is being built at a cost of $83,000. Equipment will consist of two grit chambers, screens, a comminutor, two mechanically-cleaned settling tanks having a 2-hour detention period, two heated floating-cover digestion tanks with a capacity of 2.25 cubic feet per capita, and one covered and two open drying beds having an area of 0.75 square foot per capita. The new plant will treat the sewage of the entire town and allow the abandonment of the old sand filters, which the Department of Public Health considers inadequate. Effluent will be discharged into the Connecticut River where greater dilution will be available, thus permitting only primary treatment.

Northampton. - In the north-central section of the town two municipal outfalls and several private outlets discharge domestic wastes into tributaries of the Mill River. Sewage from the central and southern sections of the town is discharged through four outlets, directly into the Mill River only a few miles above its mouth. The Mill River is considered one of the most contaminated streams in the state and contributes a substantial amount of pollution to the main stream. For many years the Department of Public Health has been recommending that a suitable outlet be provided for discharging the wastes of Northampton directly into the Connecticut River but to date no such extension has been made. The Federal Government's flood control project for local protection of Northampton involves the diversion of the Mill River near the Northampton Electric Light Company plant. Preference for this plan of flood protection, in lieu of levees and walls along the Mill River, was expressed by the City Council. The diversion of the flow of the Mill River will create a more serious pollution situation. Early construction of sewage-treatment works is necessary to avoid an objectionable and unhealthful situation in the lower reaches of the present river channel after diversion is effected.

Easthampton. - There are several private outlets discharging into Nashawannuck Pond or to Lower Mill Pond, both of which empty into the Manhan River. In addition, six large municipal outlets and many private outlets discharge into the Manhan River. The town has a sewage-treatment plant consisting of settling tanks, sludge beds, and sand filters. The works are inadequate, however, being capable of treating only about 75 percent of the sewage in the settling tanks and about 15 percent of the settled sewage in the sand filters. The Department of Public Health has recommended that Northampton and Easthampton locate a joint treatment plant at the Oxbow. This site is of sufficient size and topographically favorable for both towns. The effluent could be discharged into the Connecticut River, removing all pollution from the Mill and Manhan Rivers, two of the most polluted streams in the state. Neither town has acted on this recommendation.

South Hadley. - The chief sources of trade wastes are three paper mills discharging either into tributary brooks or into the Connecticut River itself. In addition, there are two separate sewerage systems in South Hadley Center and four municipal outlets at South Hadley Falls. A plant has been proposed for treating the domestic and industrial wastes from the village of South Hadley Center. Preliminary plans call for mechanically-cleaned screens and settling tanks, separate sludge digestion tanks, and open sludge drying beds. The effluent would be carried directly to the Connecticut River.

Holyoke. - A municipal sewerage system discharges untreated domestic and industrial wastes into the Connecticut River through fifteen outlets, from 10 inches to 9 feet 6 inches in diameter. Certain recommendations have been made for the collection and treatment of sewage. Massachusetts House Document No. 1735[10] states,

> ". . . the engineers of the Works Progress Administration have made a preliminary study for the collection of the sewage at treatment works in the southerly portion of the city. The collection of the sewage in Holyoke is a difficult problem, due to the large amount of industrial wastes and the fact that the canal system and the various tailraces at certain mills make it economically impossible to construct intercepting sewers by means of which the sewage can be removed by gravity. It appears possible, however, to construct a sewer to intercept the dry weather flow of

sewage from all of the existing sewers, with the possible exception of the sewer at Smith's Ferry, and to carry the sewage in a southerly direction where it can be pumped to treatment works. In the collection of the sewage in this manner four or five pumping stations would be required, and it would be necessary to install pumps for pumping the sewage and industrial wastes from the paper mills."

Two possible sites are suggested, one on municipal land in the industrial section of the city, and the other near the West Springfield-Holyoke town line. The first is close to population concentration and would require covered works, but the other is reasonably well isolated, permitting an open plant.

<u>Chicopee.</u> - A municipal sewerage system discharges untreated domestic and industrial wastes from Chicopee into the Connecticut River. According to Massachusetts House Document No. 1735[10]:

> "The collection of the sewage of this city will require the construction of long, intercepting sewers, along both the Chicopee and the Connecticut Rivers. The pressing problem appears to be in the collection of the sewage from the center of the city, and judging from the preliminary examinations a suitable site for treatment works at no great distance from the center of population can be selected. It is probable, however, that most of the sewage must be pumped."

<u>West Springfield.</u> - About half of the town is sewered into the Connecticut River through six outlets, five 12-inch and one 10-inch, discharging the domestic wastes of about 4600 people. Industrial waste volumes are negligible.

<u>Springfield.</u> - Springfield has a municipal sewerage system designed to carry sanitary sewage, industrial wastes, and storm water into both the Chicopee and Connecticut Rivers. Two treatment plants are now being built, one for the main portion of the city, and the other to serve the Indian Orchard section draining into the Chicopee River. The main plant is situated on Bondi's Island, at the mouth of the Westfield River in Agawam. This location necessitated the construction of an intercepting sewer along the entire length of the Connecticut River in Springfield. The plant is designed to treat 30,000,000 gallons per day from a population of 190,000. The works will consist of two mechanically-cleaned grit chambers, screens and comminutors, four mechanically-cleaned settling tanks giving a two-hour detention period, and four heated floating-cover sludge digestion tanks with a capacity of one cubic foot per capita. The digested sludge will be elutriated, conditioned with chemicals, dewatered upon vacuum filters, and incinerated. The gas from the digestion tanks will be used for incinerator fuel and for heating purposes. A 15-foot levee has been built around the plant by the City of Springfield. The other plant is designed for a daily flow of 3,000,000 gallons from a population of 20,000, including 10,000 equivalent population for industrial wastes. Treatment will be the same as at the main

plant except that the digested sludge, after drying on covered beds having an area of 0.5 square foot per capita, is to be used for fill. The effluents of these plants will not be chlorinated but provisions are being made for future installation of chlorinators. Estimated cost of the project, including the interceptors and both treatment plants, is $2,700,000.

Agawam. - The portion of the town draining into the Connecticut River has a municipal sewerage system serving 2500 people and one industrial plant. At an estimated cost of $500,000, the town is constructing interceptors which will carry the sewage now being discharged into the Connecticut and Westfield Rivers to the main treatment plant of the City of Springfield.

Longmeadow. - A municipal sewerage system discharges raw sewage into the Connecticut River. Sand filters formerly used by the town have been abandoned. Abundance of uninhabited land along the river would make it relatively simple to construct an interceptor and treatment plant.

East Longmeadow. - The town, having had no municipal sewerage system in the past, is now constructing a separate system and a plant to give complete purification. The plant will have a capacity of 380,000 gallons per day, serving 4300 persons. Equipment will consist of a manually-cleaned bar screen, an Imhoff tank giving a two-hour detention period and providing 2.0 cubic feet of sludge storage per capita, a covered trickling filter operating at the rate of 3,000,000 gallons per acre per day, a secondary tank having 48 minutes' detention, and a chlorination tank giving 11.5 minutes' detention. Sludge will be dried on covered beds having an area of 0.32 square foot per capita. Since the town does not border on the Connecticut River or any large tributary, complete treatment is required. The plant effluent will be discharged into a small brook tributary to the Connecticut River.

22. FARMINGTON RIVER. - Pollution problems on the headwaters of the Farmington River in Massachusetts are very slight because the land is sparsely populated, largely state-owned and restricted, and partly used for water-supply purposes by the Metropolitan District of Hartford. The major sources of pollution on the Farmington River in Connecticut are listed below in downstream order.

Winsted. -The city, located on the Mad and Still Rivers which flow into the West Branch Farmington River, has no municipal sewerage system except for storm water. Domestic and industrial wastes are discharged into the two rivers through several private outlets. Most of the industrial wastes, consisting of oils, metal and plating wastes, dyes, and soaps, are discharged into Mad River.

Bristol. - This town is drained chiefly by the Pequabuck River, a tributary of the Farmington River. A separate sewerage system and treatment plant serve 60 to 75 percent of the population. Treatment is complete and the maximum capacity of the plant easily accommodates average sewage flows. Bristol, an industrial town, discharges its trade wastes into the Pequabuck River without treatment. These are mostly pickling and plating wastes, acidifying the river water.

Farmington. - The Borough of Farmington has a sanitary sewer system serving 90 percent of the population and discharging untreated wastes into the Pequabuck and Farmington Rivers. The Borough of Unionville has a storm-water system which has been tapped by house connections, converting it into a combined system. The majority of the inhabitants, however, use rural disposal methods. Unionville also contributes industrial wastes from paper manufacturing.

Counteracting these pollution sources are several reaches in the river where self-purification occurs, making the stream, in general, relatively clean as shown by the water analyses in Paragraph 14d.

23. CONNECTICUT RIVER IN CONNECTICUT. - From the standpoint of sewage treatment the Connecticut River Basin in Connecticut has a larger portion of its population served by treatment plants than any other state in the watershed. Paragraph 11 shows that 36.3 percent of the inhabitants in the entire basin are connected to plants. It can further be shown that about 63 percent of the Connecticut population is served by treatment. It is therefore not surprising to find that the river in this state is in good condition despite the density of population. Water analyses in Paragraph 14d indicate the degree of pollution on the Connecticut River as it leaves Massachusetts and on certain tributaries. Following, in downstream order, is a description of localities whose sanitary conditions and facilities are worth noting:

Thompsonville. - This is the first major source of pollution after the river enters Connecticut. A recently completed sewage-disposal plant, serving about 6000 people, is in operation opposite Kings Island. The plant provides screening, grit removal, sedimentation, vacuum filtration, and incineration of filter cake. The contemplated inclusion of carpet factory wastes, consisting mainly of fiber, soaps, and dyestuffs, will increase the sewage volume by more than 50 percent and, in addition, will increase the organic content of the wastes reaching the works. This is the only plant in Connecticut where such a large-scale treatment of industrial wastes is contemplated. It will be necessary to construct a pumping station and a one-mile interceptor to carry these wastes to the treatment works.

Scantic River. - This tributary is polluted mainly by the domestic wastes of about 3000 persons at East Windsor. In addition, large quantities of wastes from the Broad Brook woolen mill are discharged here, tending to make the stream slightly alkaline. Some pollution originates at Somers, at the headwaters, but self-purification has taken place by the time the stream reaches East Windsor.

Metropolitan Sewerage District[12]. - To eliminate the need for a high degree of purification in the towns draining into the Park River and smaller tributaries on the west side of the Connecticut River near Hartford, it was deemed advisable to form the Metropolitan Sewerage District, made up of Hartford and surrounding towns, having an interconnected sewerage system leading to a single treatment plant discharging its effluent into the main stream. This system has been constructed and the treatment plant, designed to serve a population of 300,000, has recently been placed in operation. The towns served include West Hartford, and parts of Wethersfield, Newington, Bloomfield, and Windsor. Equipment consists of mechanically-cleaned screens, grit chambers and comminutors, preliminary sedimentation tanks, and heated sludge digestion tanks. The sludge will be elutriated and filtered, with the filter cake being dumped nearby for public use as fertilizer or fill. The digestion gas is recovered and used for fuel and heating. The State Department of Health has approved recommendations of consultants that sewage be treated when the river stage on the Memorial Bridge gage is under 5 feet, that sewage be only screened at stages between 5 and 10 feet, and that raw sewage be pumped directly into the river when the stage exceeds 10 feet. The putting into operation of the plant has been a major factor in reducing pollution of the lower Connecticut River.

New Britain. - The city has a public sewerage system and a new $400,000 treatment plant which was placed in operation in 1937. The present connected population is about 70,000. Treatment is by a modified chemical method known as the Guggenheim Process. The sewage is subjected to sedimentation, addition to the raw and settled sewage of varying quantities of sludge obtained from the sediment which collects in the final settling tank, flocculation by compressed air after addition of the chemicals and the returned sludge, and final sedimentation.

Hockanum River. - The analyses given in Paragraph 14d show that the Hockanum River is badly polluted at the mouth. At Rockville, located on the headwaters, there is a treatment plant having a capacity of 2,000,000 gallons per day and serving about 10,000 persons. Industrial wastes are also treated and during working house the flow increases to about 4,000,000 gallons per day. These trade wastes include fibrous material, soaps, and dyes from wool and rayon processing. The plant is obviously overloaded, resulting in complaints by downstream riparian owners. Upon orders of the State Water Commission, plans have been drawn up and approved for increasing the capacity to 6,000,000 gallons per day. Manchester has two treatment plants, one serving the north and the other the south district. The recently completed north plant is operating at a rate of 500,000 gallons per day and provides sedimentation, sludge digestion, and chlorination of effluent during the summer. The south plant handles about 2,000,000 gallons daily, and provides preliminary treatment for the wastes of 12,000 people as well as caring for the trade wastes of the paper and silk mills. At East Hartford there is no treatment plant and all wastes are discharged directly into the river. A treatment plant, having a capacity of 6,000,000 gallons per day, and providing screening, grit removal, sedimentation, heated sludge digestion, vacuum filtration, and chlorination of effluent has been proposed. The installation of this plant would remove the last major source of sewage pollution of the Connecticut River in Connecticut.

Middletown. - A new treatment plant, serving 12,000 people, was placed in operation in 1937. Equipment consists of mechanically-cleaned bar screens, sedimentation tanks giving two-hour detention, heated sludge digestion tanks, and vacuum filters. The effluent is chlorinated and discharged into the Connecticut River. The dried sludge is dumped nearby for public use.

The State of Connecticut has developed a policy of building treatment plants at public institutions[13, 14] as examples for municipalities and industrial corporations to follow. These plants are designed to give at least the minimum treatment required for the stream into which they discharge. Efficiently operated Imhoff tanks and sand filters are in use at Cedarcrest Sanatorium in Newington, U. S. Veterans Home in Rocky Hill, and at the State Hospital in Middletown. At Cedarcrest a large laundry waste treatment tank is also being operated by the State.

Stream Flows

24. MINIMUM FLOWS. - Discharge records for United States Geological Survey gaging stations show that low minimum flows have been recorded on streams of the Connecticut River Watershed, particularly during August, September, and October of the drought years 1929-1931. Many of the low flows are accentuated by upstream storage regulation. Table XXV, following, lists the lowest daily discharges for the more important stations in the basin, as determined from Water-Supply Paper 821 and preliminary tables for periods subsequent to September 30, 1937.

(Table on following page)

TABLE XX

MINIMUM FLOWS - CONNECTICUT RIVER WATERSHED

River	Gaging station	Period of record	Drainage area, square miles	Minimum average daily discharge: cu. ft. per sec.	Minimum average daily discharge: cu. ft. per sec. per sq. mi.
Connecticut	Pittsburg, N. H.	4/17-9/37	83.0	3	.036
"	N. Stratford, N.H.	8/30-9/37	796	150	.189
"	Dalton, N. H.	3/27-9/37	1538	80	.052
"	S. Newbury, Vt.	7/18-9/37	2825	222	.078
"	White River Jct., Vt.	10/11-9/37	4068	560	.138
"	Montague City, Mass.	10/29-9/37	7840	597	.076
"	Thompsonville, Mass.	7/28-9/38	9637	1310	.136
Passumpsic	Passumpsic, Vt.	11/28-9/37	423	40	.094
Moose	St. Johnsbury, Vt.	8/28-9/37	126	8	.064
Ammonoosuc	Bath, N. H.	9/35-9/38	393	50	.127
White	West Hartford, Vt.	6/15-9/37	690	39	.057
Mascoma	Mascoma, N. H.	8/23-9/37	153	2	.013
Sugar	W. Claremont, N.H.	10/28-9/38	269	31	.115
Black	N. Springfield, Vt.	11/29-9/37	158	17	.108
West	Newfane, Vt.	9/19-9/37	308	20	.065
Ashuelot	Hinsdale, N.H.	3/07-9/38	420	12	.029
Millers	Winchendon, Mass.	6/16-10/39	83.8	3.1	.037
"	Erving, Mass.	8/14-9/38	370	8	.022
Deerfield	Charlemont, Mass.	6/13-9/38	362	5	.014
Ware	Gibbs Crossing, Mass.	8/12-9/37	199	6	.030
Swift	W. Ware, Mass.	8/10-9/37	186	22	.118
Quaboag	W. Brimfield, Mass.	8/09-9/37	151	7.8	.052
Chicopee	Bircham Bend, Mass.	8/28-9/38	703	16	.023
Westfield	Westfield, Mass.	6/14-9/38	497	61	.123
Scantic	Broad Brook, Conn.	8/28-12/38	98.4	17	.173
Farmington	Tariffville, Conn.	8/28-9/38	578	175	.302
Hockanum	E. Hartford, Conn.	10/19-9/38	74.5	1.2	.016

A recent report[12] indicates that the Connecticut River at Holyoke may have a flow as low as 0.25 second-foot per square mile for one to three weeks in a single year. Due to closing of gates and storage of water at Holyoke Dam, daily flows as low as 0.017 second-foot per square mile have resulted. At Hartford the following low discharges may be expected:

Period	Discharge, cubic feet per second per square mile
One day	0.03
One week	0.18
Possible single month	0.10
Possible three-month period	0.25
Minimum month in an average year	0.50

Evaluation of the above low flows on a basis of population equivalents is complicated by the fact that much opportunity for sedimentation and self-purification exists with major pollution sources dispersed along the river's length. Except for local nuisances, objectionable conditions were not in evidence, even prior to the installation of new treatment plants.

25. DIVERSION OF FLOW. - To furnish water for Metropolitan Boston, large areas drained by the Swift and Ware Rivers are being used by the Metropolitan District Water Supply Commission. The diversions were contested by the State of Connecticut on the grounds that during low-flow periods unsanitary conditions would be aggravated on the lower river. To prevent such nuisances and protect navigation, rules governing diversions and releases for the water-supply developments were promulgated by War Department rulings of March 1928 and May 1929, and by Massachusetts Legislation drawn up by the State Department of Public Health. The restrictions in effect are outlined in Table XXXI, following:

TABLE XXXI

RULES FOR COMPUTING DIVERSIONS ON THE WARE RIVER AND DIVERSIONS AND RELEASES ON THE SWIFT RIVER

Period of year	River	Rule	Diversion
Dec. 1 to May 31	Ware	Massachusetts	All over 85 M.G.D. (131.5 c.f.s.)
	Swift	"	All over 20 M.G.D. (31 c.f.s.) at Bondsville
June 1 to June 14	Ware	"	All over 85 M.G.D. (131.5 c.f.s) but only with permission of State Department of Public Health
	Swift	War Department	*
June 15 to Oct. 14	Ware	" "	None
	Swift	" "	*
Oct. 15 to Nov. 30	Ware	Massachusetts	All over 85 M.G.D. (131.5 c.f.s.) but only with permission of State Department of Public Health
	Swift	War Department	*

*Divert all over 20 M.G.D. (31 c.f.s.) at Bondsville except (a) when flow of Connecticut River at Montague City is 4650-4900 second-feet, 70 second-feet must be maintained; and (b) when Montague City flow is 4650 second-feet or less, 110 second-feet must be maintained.

These diversions, while having relatively slight effect on the sanitary condition of the main stream, would aggravate pollution problems on the Chicopee River were it not for the Federal and State regulations.

26. *EFFECT OF FLOOD CONTROL WORKS UPON WATERWAY POLLUTION.*

a. Reservoirs. - The operation of storage reservoirs for the sole purpose of reducing flood discharges provides valuable sanitation benefits. Although no significant improvement in low-water flow may be expected, since the reservoirs will be regulated solely to keep flood losses at a minimum and will therefore be emptied as soon after heavy rains as downstream conditions permit, there will be definite sanitation benefits, as enumerated below.

(1) Protection of sewage-treatment plants. - Sewage-treatment plants are commonly located at the lowest suitable elevation, to permit collection of sewage by gravity and reduce pumping costs. With few exceptions the cities and larger sewered towns in the basin are situated near rivers, into which the disposal of wastes, either raw or treated, is the cheapest and most convenient means of removal. In the Connecticut River Watershed, most treatment plants are located on flood plains downstream from the population centers they serve. In floods, such as have recently occurred, major disruptions are caused by high water at treatment plants in the valleys. Each flooding necessitates the discharge of raw sewage and major delays result before the normal operating cycle of a plant can be restored. As in the starting of a new treatment plant, several weeks may elapse before bacteriological processes are in equilibrium. Flooding of a sewage-disposal plant generally backs up sludge into sewer mains, where it hardens, necessitating extensive cleaning and repairs. In addition, there is the cost of remedying actual physical damage to the plant, and of cleaning up and disinfecting flooded-area property near inundated treatment works. Control of flood waters therefore provides incalculable sanitation benefits by assuring continued operation of treatment plants.

(2) Diminution of pollution load. - By keeping streams in their normal channels, operation of flood control works results in less flooding of sewers, outhouses, cesspools, septic tanks, and refuse dumps, with less of their wastes reaching streams.

(3) Sedimentation in storage basins. - Storage of water in reservoirs results in a settling action, reducing the content of suspended solids. If there are pollution sources upstream, a reservoir pool lessens the content of contaminating suspended material, rendering the water more capable of bearing downstream pollution loads. Little sedimentation would occur at reservoirs operated for flood control alone, since pools would normally be drawn down.

(4) Aeration. - Through aeration provided at outlet structures, some increase in dissolved oxygen content may be expected at flood control dams. In most cases water discharging from flood control reservoirs will be saturated with oxygen, allowing the oxidation of a maximum quantity of wastes to less objectionable substances.

(5) "Flood flushing" effect. - Some sanitary engineers are of the opinion that control of flood waters by upstream regulation will result in rivers losing the natural flushing action provided by the sudden increase in stream velocities and discharges during floods. In opposition it may be stated that the same volume of water will be available for the flushing process, but that it will be more advantageously used over a longer duration. A given amount of solvent will extract a larger amount of dissolved solids if used in several smaller volume extractions than in one extraction using all solvent volume at once. A brief sudden discharge may also be less effective, in that solids will only be moved a short distance downstream. Less obstructions to stream flow are apt to be encountered in controlled floods than under natural conditions.

(6) Benefits to water supplies. - Flood control will decrease health hazards occasioned by contamination of municipal and private water supplies through direct flooding, rupture of mains, and cross connections in flood areas. In the clean-up periods following the floods of 1936 and 1938, state and local health departments required special precautions before use of flooded ground-water supplies could be resumed.

b. Levees. - Levees, protecting heavily populated areas from flood waters, have already benefited the cause of pollution abatement. In the March 1936 flood, the Metropolitan Sewerage District treatment plant, then under construction in the Hartford South Meadows, was inundated to a twenty-foot depth causing a direct loss of about $50,000 and several months' delay in completion. Raising of the Clark Dike and emergency protection of the Colt Dike during the September 1938 flood protected the treatment plant, which was then in operation. Completion of the local protection works now under construction at Hartford will fully protect the treatment plant which serves six towns and in capacity is the largest in New England. The City of Springfield has built a ring-dike on Bondi's Island to protect the treatment plant being constructed to serve Springfield and Agawam. Serious loss occurred in the 1936 and 1938 floods at the Middletown, Connecticut, treatment plant and at Greenfield, Massachusetts, where a plant, started in 1935, is being built. Prior to completion of levees and wells in West Springfield, $70,000 flood damage to sewers in the Riverdale section was reported in 1936.

c. Channel improvements. - Present conditions at Winsted, Connecticut, are such that during freshets water from the Mad River can cause sewers to back up. The proposed channel improvement will alleviate resultant unsanitary conditions in the center of the city.

27. <u>POLLUTION ABATEMENT BY CONSERVATION STORAGE</u>. - Through dilution provided by conservation storage, the concentration of objectionable wastes may be reduced to a degree comparable with partial treatment. Direct and complete treatment is preferable. With the state health departments striving to improve the Connecticut River for recreational purposes, mere dilution of wastes would be inadequate, since removal of organic solids is prerequisite to such uses as fish propagation, bathing, camping, and pleasure boating. Dilution alleviates objectionable conditions and, if conservation storage can be provided at a low per acre-foot cost, it may be desirable as an additional measure, especially during the time until the construction of treatment plants can be financed. An evaluation of benefits for pollution abatement by conservation storage to increase low-water flows does not warrant the construction by the United States of multiple-purpose reservoirs for this purpose. Local governments may find it warranted when combined with other purposes and local advantages.

28. SUMMARY.

a. New England relies heavily on the Connecticut River Basin for water-supply and recreational purposes. Steps to prevent indiscriminate waterway pollution will in the future more than repay their costs. Because of the contamination of waters near population centers, growing communities are forced to go increasing distances to supplement their supplies. At a cost of about $65,000,000 it was necessary for the Boston Metropolitan District to go into the Connecticut River watershed, over 60 miles away, to secure water of suitable quality, because all natural waters in eastern Massachusetts were so polluted as to be undesirable. Hartford recently spent $8,000,000 to develop an additional supply in the upper Farmington River Valley. According to the Massachusetts health department, the Connecticut River has not yet reached the nuisance stage and even below Springfield is not as objectionable as other Massachusetts streams were when mandatory legislation was adopted to reduce their pollution.

b. Although no formal agreements to accomplish pollution abatement have been entered into by the states concerned, a general cooperative interest is being shown with the result that each year finds great progress in the treatment of Connecticut River Valley wastes. Whereas in 1936 only 12 percent of the population on the watershed were served by sewage-disposal plants, the figure is now 36 percent, and with completion of works under construction or proposed, 52 percent, representing nearly all sewered population, will be served by treatment plants. Where sewerage or treatment facilities are inadequate, the responsible state agencies are urging municipalities to have engineering surveys made, and are advising communities as to the best solutions of their waste-disposal problems. Economic conditions in the Connecticut River Watershed are generally more favorable than in adjoining sections so that fewer financial obstacles confront pollution abatement.

c. Considerable pollution exists on the following streams: Mill (of Northampton), Manhan, lower Chicopee, and Hockanum Rivers. Moderate pollution is found on the Connecticut, Mascoma, Sugar, Ashuelot, Millers, lower Deerfield, Green, upper Chicopee, lower Westfield, and Farmington Rivers. Little pollution exists on the Passumpsic, Ammonoosuc, White, West, Scantic, and Salmon Rivers.

d. With population centers widely scattered along the streams, much opportunity for self-purification is afforded between pollution sources. It is generally agreed that the Connecticut River can well take care of the present untreated wastes emanating from points above Massachusetts.

e. The industrial waste problem is not so acute as on other watersheds. A mitigating factor is the wide diversification of industry, both on the main stream and tributaries. At Holyoke over 39,000,000 gallons of trade wastes are discharged into the Connecticut River each day, but these are mostly inoffensive rinse waters from paper manufacture. In Connecticut, some concerns are using industrial waste treatment plants to effect stream betterment and recovery of by-products. Experiments to develop methods of treating wastes are being continued by the State Water Commission.

f. Disposal of refuse by dumping into streams or on river banks below high-water level, in violation of local and state ordinances, is a general practice at some industrial plants and in population centers.

g. Several of the tributaries have experienced extremely low flows during droughts but nuisance conditions attributed to this cause are rare. Flows on the main river are ordinarily ample to carry the pollution load.

h. Operation of flood control reservoirs will provide numerous incidental sanitation benefits, such as (1) protection of sewage-treatment plants, (2) diminution of pollution load picked up by high flood stages, (3) sedimentation in storage basins, (4) aeration at outlet structures, (5) more effective stream flushing, and (6) benefits to water supplies.

29. CONCLUSIONS.

a. Effective sewage-disposal plants for domestic wastes should be constructed for all communities where none now exist.

b. As rapidly as finances permit treatment plants, central or individual, should be established for all industries or factories releasing trade wastes or contaminated waters.

c. Construction of new treatment plants, if continued at the present rate, should result in abatement of all important pollution sources within a generation.

d. The comprehensive pollution abatement problem in the entire watershed resolves itself into the treatment of wastes rather than the providing of dilution. In general, conservation storage, while helpful in pollution abatement, is not necessary because of waste treatment plants, existing and under construction, at major pollution sources.

e. Expenditures by the United States for additional storage for pollution abatement in flood control reservoirs is not justified by an evaluation of benefits therefor. Additional local benefits and advantages may warrant provision of such storage by local interests.

f. Laws enabling state authorities to force cessation of pollution, prevent new sources, establish regulations for pollution abatement and control are desirable.

g. Formulation of interstate agreements between New Hampshire, Vermont, Massachusetts, and Connecticut, with the ultimate objective of setting purification standards for the Connecticut River, is desirable. There now is wide divergence in the abatement laws of the states concerned.

h. Should the water at any dam site have a low dissolved oxygen content, design of outlets could be such as to provide beneficial aeration, securing downstream sanitation benefits. Reduction in water hardness by dilution is unnecessary, since the natural waters are already sufficiently soft.

i. Continuation of research to develop methods of industrial waste treatment is commended, and with improvement in the economics of waste treatment, other plant owners should be encouraged to make installations voluntarily.

j. Periodic sampling and analysis of river waters in Massachusetts and Connecticut furnishes the evidence necessary to control properly the quality of waters. Lack of such programs in New Hampshire and Vermont may result in wilful pollution.

k. To abate pollution caused by dumping of refuse into streams, town, city, and state authorities should provide more suitable dumping grounds, establish regulations for refuse disposal, and, when necessary, prosecute violators.

l. At levees and channel-improvement locations, local policing to prevent the dumping of refuse is recommended. Projects in some localities have lost part of their flood controlling effect, due to the silting-in of channels primarily by the dumping of refuse into the streambed.

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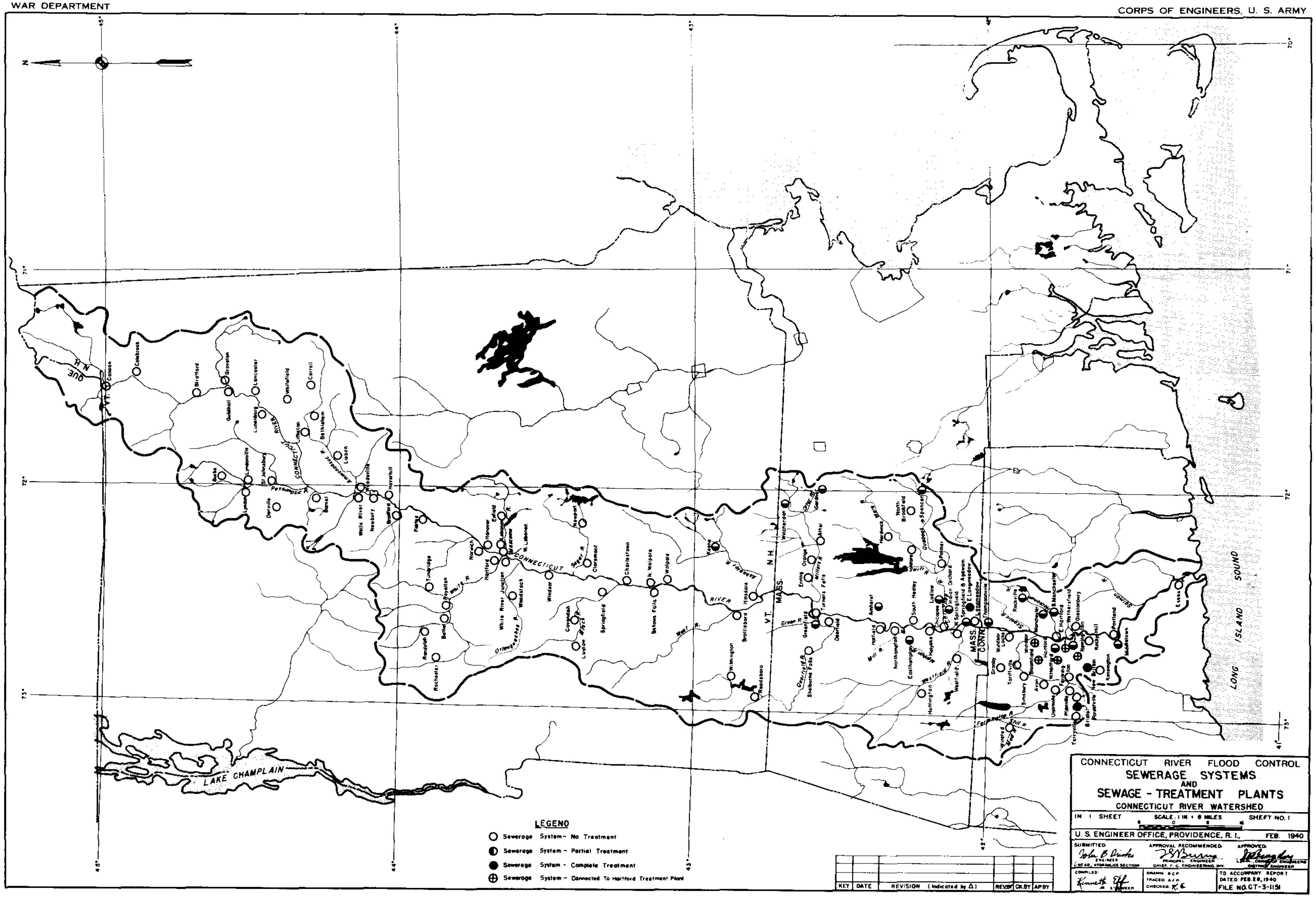
LAKE CHAMPLAIN
CONNECTICUT RIVER
LONG ISLAND SOUND
VT.
N.H.
MASS.
CONN.
QUE.
LEGEND
Sewerage System - No Treatment
Sewerage System - Partial Treatment
Sewerage System - Complete Treatment
Sewerage System - Connected To Hartford Treatment Plant
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AND
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TO ACCOMPANY REPORT
DATED FEB. 29, 1940
FILE NO. CT-3-1151

SECTION 4

POWER

SECTION 4

POWER

1. SCOPE. - In this section are presented summaries of the existing and possible future hydroelectric power developments within the Connecticut River Basin, data pertinent to the potential development of hydroelectric power at flood control sites in conjunction with flood control storage, and data pertaining to potential conservation storage at flood control sites. Many of the basic data presented herein were obtained from House Document No. 412, Seventy-fourth Congress, second session, and from Section 1 of the Appendix (unprinted) of the Report on Survey and Comprehensive Plan for Flood Control printed in House Document No. 455, Seventy-fifth Congress, second session.

2. EXISTING HYDROELECTRIC DEVELOPMENTS. - A tabulation of the 58 active hydroelectric developments in the Connecticut River Basin producing power for sale is given in Table XXXII. Of the total generating capacity of 456,000 kilowatts, 296,000 kilowatts, or about 65 percent, are located on the main Connecticut River, and 99,000 kilowatts, or about 22 percent, are located on the Deerfield River. The tabulation includes a column showing the developed discharge at the various plants in cubic feet per second per square mile. With the exception of the recently constructed plant at Lower Fifteen Mile Falls on the Connecticut River, the Harriman plant on the Deerfield River, and a few relatively small plants, the developed flows are not high, indicating that a major portion of the hydroelectric generating capacity in the region operates at a high load factor. This fact, in turn, indicates that there is little demand for new peak load stations operating at low load factors.

3. POTENTIAL HYDROELECTRIC POWER DEVELOPMENT. - No new studies have been made of the possibilities of power development at sites other

TABLE XXXII

EXISTING HYDROELECTRIC DEVELOPMENTS IN THE CONNECTICUT RIVER BASIN PRODUCING POWER FOR SALE

RIVER	LOCATION		GROSS HEAD IN FEET	INSTALLED CAPACITY IN KILOWATTS	DRAINAGE AREA IN SQ. MILES	PLANT CAPACITY C.F.S./SQ.MI.
CONNECTICUT	CANAAN, VT.		37.7	1,100	378	1.2
"	LYMAN FALLS, VT.		31.6	1,000	640	0.7
"	LOWER FIFTEEN MILE FALLS, N. H.		176.0	140,000	1,663	7.2
"	McINDOE FALLS, VT.		32.4	10,000	2,233	2.1
"	WILDER, VT.		35.0	3,120	3,367	0.4
"	BELLOWS FALLS, VT.		63.0	45,000	5,387	2.0
"	VERNON, VT.		36.0	28,000	6,239	1.8
"	TURNERS FALLS NO. 2, MASS.	*	67.4	52,000	7,138	1.8
"	TURNERS FALLS NO. 1, MASS.	*	60.0	5,000		
"	HOLYOKE NO. 1, MASS.	*	24.0	7,030		
"	HOLYOKE NO. 2, MASS.		20.0	2,900	8,242	1.0
"	HOLYOKE (MUNICIPAL), MASS.		12.0	1,050		
"	WINDSOR LOCKS, CONN.	*	28.0	2,900	9,655	0.01
AMMONOOSUC	BETHLEHEM, N. H.		46.3	300	90	0.98
"	LITTLETON, N. H.		18.7	100	120	0.67
"	LISBON, N. H.		16.3	300	288	0.96
ASHUELOT	MARLBORO, N. H.		269.0	1,600	25	3.56
"	SWANZEY NO. 1, N. H.		16.0	120	97	1.16
"	SWANZEY NO. 2, N. H.		18.0	120	99	1.01
"	TROY, N. H.		16.4	150	27	5.07
BLACK	CAVENDISH, VT.		120.9	1,500	32	2.27
"	PERKINSVILLE, VT.		22.3	370	117	2.12
CHICOPEE	INDIAN ORCHARD, MASS.		30.3	6,100	687	3.7
"	CHICOPEE, MASS.		36.2	2,100	720	1.2
"	BLANCHARDVILLE, MASS.		16.0	1,125	179	0.6
DEERFIELD	SEARSBURG, VT.		230.0	5,000	96	3.4
"	WHITINGHAM (HARRIMAN), VT.		390.0	45,000	184	9.4
"	ROWE (SHERMAN), MASS.		80.0	7,000	234	5.6
"	FLORIDA NO. 5, MASS.		240.0	17,000	250	4.25
"	SHELBURNE FALLS NO. 4, MASS.		64.0	7,000	402	4.07
"	SHELBURNE FALLS NO. 3, MASS.		66.0	7,000	407	3.20
"	GARDNERS FALLS (SHELBURNE), MASS.		40.0	4,000	500	3.00
"	SHELBURNE FALLS NO. 2, MASS.		60.0	7,000	502	3.49
FARMINGTON	TARIFFVILLE, CONN.		32.8	1,800	578	1.4
"	ROBERTSVILLE, CONN.		55.6	500	48	2.80
"	RAINBOW, CONN.		60.0	8,000	590	3.4
"	UNIONVILLE, CONN.		36.0	1,600	330	1.76
"	UNIONVILLE, CONN.		18.0	150	330	0.32
ISRAEL	LANCASTER, N. H.		25.0	130	120	0.64
MASCOMA	LEBANON NO. 1, N. H.		18.7	150	188	0.67
"	LEBANON NO. 2, N. H.		16.2	140	194	0.67
"	LEBANON NO. 3, N. H.		71.7	1,050	194	1.19
MILLERS	WINCHENDON NO. 1, MASS.		20.5	350	55	4.65
"	FARLEY, MASS.		18.0	360	384	0.78
MILL BROOK	WINDSOR, VT.		40.0	300	44	2.55
PASSUMPSIC	PASSUMPSIC NO. 4, VT.		24.1	700	425	1.0
"	ST. JOHNSBURY NO. 0, VT.		17.2	250	220	1.0
"	ST. JOHNSBURY NO. 2, VT.		9.6	150	376	0.6
"	ST. JOHNSBURY NO. 3, VT.		17.0	875	420	1.8
"	WEST DANVILLE, VT.		171.3	1,000	20	3.0
"	LYNDONVILLE, VT.		15.3	60	220	0.27
"	LYNDONVILLE, VT.		61.1	600	220	0.67
SUGAR	CLAREMONT, N. H.		24.0	250	250	0.65
"	SUNAPEE, N. H.		71.0	500	46	2.57
"	SUNAPEE, N. H.		58.0	470	46	2.64
WAITS	BRADFORD, VT.		73.4	360	154	0.48
WELLS	BOLTONVILLE, VT.		66.9	470	87	0.12
WESTFIELD	COBBLE MOUNTAIN, MASS.		430.0	23,000	45.8	1.75
WHITE	ROYALTON, VT.		13.1	560	410	1.56
	TOTAL			455,870		

* LARGE VOLUME OF WATER SOLD TO INDUSTRIES.

other than flood control sites. The information presented herein was taken from the previously mentioned documents. Table XXXIII lists the possible new developments or redevelopments within the Connecticut River Watershed that are located downstream from proposed flood control sites. For all the Connecticut River sites listed, it was found in House Document No. 412 that the annual power values would exceed the annual costs. For the other sites listed on the White and West Rivers, the ratios of annual value to annual cost were between 0.8 and 1. Developments at these sites may at some future time be warranted. Benefits to them were considered in studies of the possible value of future conservation storage at flood control sites. The potential installations shown in Table XXXIII are based upon load factors of 25 percent for the plants on the Connecticut River, and 30 percent for the plants on the West and White Rivers.

4. <u>POTENTIAL HYDROELECTRIC POWER AT FLOOD CONTROL SITES</u>. - Each of the flood control sites considered in this report was investigated to determine the feasibility of constructing a higher dual-purpose dam to permit the generation of power at the site in addition to the provision of flood control storage in the upper portion of the reservoir. Exceptions to this were the Knightville, Birch Hill, Lower Naukeag, and Tully sites in Massachusetts, and the Union Village site in Vermont, for each of which the Federal Power Commission has made an independent study. That Commission recommended the provision of additional reservoir capacity at Knightville and Union Village to permit the future development of power at the sites. It recommended the provision of certain adaptations at the Tully site to enable the future raising of the dam. It indicated that it did not consider to be feasible the provision of additional capacity at the Lower Naukeag and Birch Hill sites, either for the generation of power or for conservation storage. The site at North Springfield, Vermont, was not investigated for dual use, since it is not readily fea-

TABLE XXXIII

POSSIBLE NEW DEVELOPMENTS OR REDEVELOPMENTS OF EXISTING PLANTS IN THE CONNECTICUT RIVER BASIN

Development	State	River	Drainage area in square miles	Existing head in feet	Existing Installation K.W.	Potential developed head in feet	Potential Installation K.W.
Piermont	N. H.	Connecticut	3104			28	13,000
Wilder	N. H.	Connecticut	3367	35	3,120	35	17,500
Hart Island	N. H.	Connecticut	4573			26	18,500
Holyoke	Mass.	Connecticut	8242	55	11,036	55	60,000
Enfield	Conn.	Connecticut	9655	28	2,900	28	35,000
Sharon	Vt.	White	649			57	6,000
West Hartford	Vt.	White	683			35	4,000
Hartford	Vt.	White	708			42	5,000
West Dummerston	Vt.	West	408	20	620	52	6,800
Brattleboro	Vt.	West	420			58	7,600

sible to build a higher dam at this site. Table XXXIV. furnishes pertinent data concerning the possible development of power at all other flood control sites. The assumptions used in computing these tables were as follows:

- a. A load factor of 25 percent for all developments.
- b. An over-all efficiency of 80 percent.
- c. Power values of $12.50 per kilowatt for peaking capacity, plus 1.5 mills per kilowatt hour for the energy or coal-saving value.
- d. Benefits from active draw-down storage to downstream plants similar to benefits discussed in Paragraph 5. These benefits are shown in Table XXXV.

Storage capacities selected for the power developments were chosen to give the minimum cost of development expressed in dollars per foot of usable head, with the further proviso that active storage capacity of approximately 100 acre-feet per square mile be provided for stream flow regulation. Previous studies made to determine the effect of conservation storage upon minimum flows indicated that storage capacities of this amount for reservoirs in the Connecticut River Watershed yield the greatest increase in minimum stream flow per acre-foot.

5. POTENTIAL CONSERVATION STORAGE AT FLOOD CONTROL SITES. - Each flood control site investigated in this report was further investigated to determine the feasibility of providing conservation storage capacity in addition to the flood control storage capacity. Such conservation storage, by regulating stream flow and increasing dry-weather flow, would provide important benefits to downstream communities and water users. Table XXXV is a summary of the possible benefits to be derived from additional conservation storage at each flood control site, with the exception of Knightville, Birch Hill, Lower Naukeag, and Tully in Mass-

TABLE XXXIV

ANALYSIS OF POSSIBLE POWER DEVELOPMENT AT FLOOD CONTROL SITES

Reservoir	River	Drainage area square miles	Capacities: Flood control inches	Capacities: Flood control acre-feet	Capacities: Power inches	Capacities: Power acre-feet	Capacities: Total inches	Capacities: Total acre-feet	Assumed power draw-down acre-feet	Minimum regulated flows c.f.s. per square mile	Minimum regulated flows c.f.s.	Mean usable flow c.f.s.	Water surface elevations: Maximum for power feet above m.s.l.	Water surface elevations: Tailwater feet above m.s.l.	Mean head feet	Installed capacity kilowatts	Annual output 1000 kilowatt hours	Annual value at site: Peaking capacity	Annual value at site: Output	Annual value of draw-down storage to downstream plants*	Total annual value	Annual cost: Reservoir storage	Annual cost: Power installation	Annual cost: Total	Ratio of value to cost
Massachusetts																									
Easthampton	Manhan	68	6.0	21,800	2.8	10,000	8.8	31,800	5,000	0.53	36	75	156	126	28	280	1,250	$ 3,500	$ 1,900	$ 0	$ 5,400	$ 29,000	$ 10,200	$ 39,200	0.1
Fort Morrison	Deerfield (North)	48	6.0	15,400	3.5	8,900	9.5	24,300	4,800	0.63	30	62	693	615	73	600	2,690	7,500	4,000	6,400	17,900	21,800	12,800	34,600	0.5
West Brookfield	Chicopee (Quaboag)	106	6.0	33,900	6.0	33,900	12.0	67,800	10,600	0.60	64	127	611	597	13	230	980	2,900	1,500	7,400	11,800	55,100	9,800	64,900	0.2
Barre Falls	Chicopee (Ware)	57	8.0	24,300	2.6	8,000	10.6	32,300	6,000	0.68	39	78	802	750	49	520	2,280	6,500	3,400	3,200	13,100	8,100	12,200	20,300	0.6
New Hampshire																									
Honey Hill	Ashuelot (South Branch)	70	7.0	26,200	3.0	11,000	10.0	37,300	6,000	0.45	32	63	506	472	32	280	1,200	3,500	1,800	1,900	7,200	20,600	10,200	30,800	0.2
Otter Brook	Ashuelot (Otter Brook)	47	7.0	17,500	3.0	7,500	10.0	25,000	4,500	0.49	23	44	737	618	107	670	2,800	8,400	4,200	2,400	15,000	18,900	13,400	32,300	0.5
Claremont	Sugar	245	6.0	78,400	1.6	20,200	7.6	98,600	15,200	0.36	88	172	878	525	47	1,130	4,810	14,100	7,200	13,300	34,600	38,000	17,100	55,100	0.6
West Canaan	Mascoma	80	8.0	34,100	4.5	19,400	12.5	53,500	8,000	0.57	46	86	888	801	85	1,070	4,350	13,400	6,500	5,200	25,100	13,800	18,600	32,400	0.8
Sugar Hill	Ammonoosuc	246	7.0	91,600	2.2	28,400	9.1	120,000	12,300	0.63	155	320	690	598	87	3,560	16,000	44,500	24,000	11,900	80,400	56,000	44,600	99,600	0.8
Upper 15 Mile Falls	Connecticut	1,626	3.0	260,000	2.5	216,000	5.5	476,000	114,000	0.79	1,290	2,930	806	650	150	125,000	256,000	1,562,500	384,000	204,300	2,150,800	201,000	753,000	954,000	2.3
Vermont																									
Williamsville	West	400	7.0	150,000	4.8	103,000	11.8	253,000	40,000	0.70	280	504	460	341	114	9,000	38,000	109,000	57,000	18,900	184,900	105,000	55,300	160,300	1.2
Cambridgeport	Saxtons	58	7.0	21,600	3.2	10,000	10.2	31,600	5,800	0.63	36.5	75	621	550	67	670	3,010	8,400	4,500	2,800	15,700	11,300	13,400	24,700	0.6
Brockway	Williams	101	6.0	32,300	3.7	20,000	9.7	52,300	8,000	0.54	55	112	534	450	80	1,200	5,350	16,000	8,000	6,300	29,300	48,000	17,600	65,600	0.4
Ludlow	Black	56	8.0	23,900	10.0	30,100	18.0	54,000	12,000	0.98	55	84	1,074	999	72	1,080	3,600	13,500	5,400	20,700	39,600	26,900	16,600	43,500	0.6
North Hartland	Ottauquechee	222	6.0	71,100	1.3	15,200	7.3	86,300	10,200	0.41	91	244	464	350	106	2,640	15,400	33,000	23,200	7,700	63,900	47,000	29,400	78,400	0.8
South Tunbridge	White (First Branch)	102	6.0	32,600	3.0	16,400	9.0	49,000	10,200	0.63	64	133	542	461	76	1,320	6,000	16,500	9,000	7,700	33,200	47,600	18,600	66,200	0.5
South Randolph	White (Second Branch)	63	7.0	23,500	1.9	6,500	8.9	30,000	3,000	0.41	26	63	564	533	29	200	1,090	2,500	1,600	2,400	6,500	15,700	9,600	25,300	0.3
Ayers Brook	White (Ayers Brook)	30	7.0	11,200	3.8	6,100	10.8	17,300	3,000	0.63	19	39	687	642	43	220	1,000	2,800	1,500	2,700	7,000	15,600	9,800	25,400	0.3
Gaysville	White	226	7.0	84,300	3.3	40,000	10.3	124,300	31,000	0.75	170	316	767	590	170	8,000	32,200	99,600	48,200	26,800	174,600	70,000	87,700	157,700	1.1
South Branch	Waits (South Branch)	45	7.0	16,800	10.0	24,200	17.0	41,000	15,000	1.21	55	76	826	665	154	2,300	7,000	28,800	10,800	18,200	57,500	38,700	41,300	80,000	0.7
Victory	Passumpsic (Moose)	66	8.0	28,200	15.0	52,800	23.0	81,000	20,000	1.20	79	112	1,164	990	70	1,500	4,670	18,800	7,000	15,700	41,500	20,100	20,000	40,100	1.0
Lyndonville	Passumpsic	70	7.0	26,100	1.6	6,000	8.6	32,100	4,000	0.36	46	99	791	705	80	1,000	4,730	12,800	7,000	10,600	30,100	19,000	16,500	35,500	0.8

* Taken from Table XXXV.

TABLE XXXV

ANALYSIS OF POSSIBLE DOWNSTREAM POWER BENEFITS OF CONSERVATION STORAGE AND POWER DRAW-DOWN STORAGE AT FLOOD CONTROL SITES

Reservoir	River	Drainage area square miles	Capacities: Flood control Inches	Flood control Acre-feet	Conservation Inches	Conservation Acre-feet	Power draw-down Inches	Power draw-down Acre-feet	Downstream heads: Existing Tributary	Existing Main stem	Ultimate Tributary	Ultimate Main stem	Increase of minimum flow Tributary	Increase of minimum flow Main stem
Massachusetts														
Easthampton	Manhan	68	6.0	21,800	2.8	10,000			0	0	0	83	30	22
							1.4	5,000					24	11
Fort Morrison	Deerfield (North)	48	6.0	15,400	3.5	6,900			166	0	166	83	31	20
							1.9	4,800					20	11
West Brookfield	Chicopee (Quaboag)	106	6.0	33,900	6.0	33,900			104	0	104	28	68	68
							1.9	10,600					36	23
Barre Falls	Chicopee (Ware)	57	8.0	24,300	2.6	8,000			88	0	88	28	22	18
							2.0	6,000					18	13
New Hampshire														
Honey Hill	Ashuelot (South Branch)	70	7.0	26,200	3.0	11,100			0	64	0	147	35	24
							1.6	6,000					22	13
Otter Brook	Ashuelot (Otter Brook)	47	7.0	17,500	3.0	7,500			34	64	34	147	23	17
							1.8	4,500					16	10
Claremont	Sugar	245	6.0	78,400	1.6	20,200			23	159	23	242	46	45
							1.2	16,200					33	33
West Canaan	Mascoma	80	8.0	34,100	4.5	19,400			107	159	107	268	29	29
							1.9	8,000					6	6
Sugar Hill	Ammonoosuc	246	7.0	91,600	2.2	28,400			16	159	16	331	106	63
							0.9	12,300					84	27
Upper 15 Mile Falls	Connecticut	1,626	3.0	260,000	2.5	215,000			0	373	0	545	0	476
							1.3	114,000					0	250
Vermont														
Williamsville	West	400	7.0	150,000	4.8	103,000			0	99	110	182	340	88
							1.9	40,000					220	68
Cambridgeport	Saxtons	58	7.0	21,600	3.2	10,000			0	99	0	182	24	22
							1.9	5,800					16	13
Brockway	Williams	101	6.0	32,300	3.7	20,000			0	159	0	242	73	44
							1.5	8,000					30	16
Ludlow	Black	56	8.0	23,900	10.0	30,100			143	159	143	242	72	66
							4.0	12,000					41	26
North Hartland	Ottauquechee	222	6.0	71,100	1.3	15,200			0	159	0	268	60	33
							0.9	10,200					32	22
South Tunbridge	White (First Branch)	102	6.0	32,600	3.0	16,400			0	159	134	268	65	36
							1.9	10,200					40	22
South Randolph	White (Second Branch	63	7.0	23,500	1.9	6,500			0	159	134	268	25	14
							0.9	3,000					10	7
Ayers Brook	White (Ayers Brook)	30	7.0	11,200	3.6	6,100			13	159	147	268	21	13
							1.6	3,000					13	7
Gaysville	White	226	7.0	84,300	3.3	40,000			13	159	147	268	143	88
							2.5	21,000					126	68
South Branch	Waits (South Branch)	45	7.0	16,800	[illegible]	24,200			74	159	74	331	73	53
							6.2	15,000					44	35
Victory	Passumpsic (Moose)	66	8.0	28,200	15.0	52,800			51	203	51	375	94	94
							5.7	20,000					59	44
Lyndonville	Passumpsic	70	7.0	26,100	1.6	6,000			144	203	144	375	31	13
							1.1	4,000					25	9

AT EXISTING PLANTS

Reservoir	Increased peaking capacities-kilowatts Tributary	Main stem	Total	Increased output 1000 kilowatt hours Tributary	Main stem	Total	Annual values Peaking capacity	Output	Total	Annual cost of storage	Ratio of value to cost
Massachusetts											
Easthampton	0	0	0	0	0	0	$0	$0	$0	$29,000	0
	0	0	0	0	0	0	0	0	0		
Fort Morrison	1,400	0	1,400	1,210	0	1,210	8,400	1,800	10,200	21,800	0.5
	900	0	900	650	0	650	5,400	1,000	6,400		
West Brookfield	1,920	0	1,920	3,170	0	3,170	11,500	4,800	16,300	55,100	0.3
	1,020	0	1,020	900	0	900	6,100	1,300	7,400		
Barre Falls	530	0	530	580	0	580	3,200	900	4,100	8,100	0.5
	430	0	430	430	0	430	2,600	600	3,200		
New Hampshire											
Honey Hill	0	420	420	0	580	580	2,500	900	3,400	20,600	0.2
	0	230	230	0	320	320	1,400	500	1,900		
Otter Brook	210	300	510	210	390	600	3,100	900	4,000	18,900	0.2
	150	170	320	120	340	360	1,900	500	2,400		
Claremont	300	2,000	2,300	380	2,640	3,020	13,800	4,500	18,300	38,000	0.5
	210	1,430	1,640	287	1,980	2,270	9,900	3,400	13,300		
West Canaan	840	1,260	2,110	1,710	2,540	4,250	12,700	6,300	19,000	13,800	1.4
	180	260	440	700	1,040	1,740	2,600	2,600	5,200		
Sugar Hill	460	2,720	3,180	370	3,700	4,070	19,100	6,100	25,200	55,000	0.5
	370	1,170	1,540	160	1,600	1,760	9,300	2,600	11,900		
Upper 15 Mile Falls	0	48,100	48,100	0	66,000	66,000	288,500	99,000	387,500	201,000	1.9
	0	25,400	25,400	0	34,800	34,800	152,000	52,300	204,300		
Vermont											
Williamsville	0	2,390	2,390	0	9,280	9,280	14,400	13,900	28,300	105,000	0.3
	0	2,390	2,390	0	3,240	3,240	14,400	4,800	18,900		
Cambridgeport	0	590	590	0	810	810	3,500	1,300	4,800	11,300	0.4
	0	350	350	0	470	470	2,100	700	2,800		
Brockway	0	1,900	1,900	0	2,610	2,610	11,400	3,900	15,300	48,000	0.3
	0	780	780	0	1,040	1,040	4,700	1,600	6,300		
Ludlow	2,800	2,820	5,620	3,550	3,940	7,490	34,000	11,000	45,000	26,900	1.7
	1,590	1,120	2,710	1,410	1,560	2,970	16,300	4,400	20,700		
North Hartland	0	1,470	1,470	0	1,980	1,980	8,600	3,000	11,600	47,000	0.3
	0	950	950	0	1,330	1,330	5,700	2,000	7,700		
South Tunbridge	0	1,560	1,560	0	2,140	2,140	9,400	3,200	12,600	47,600	0.3
	0	950	950	0	1,330	1,330	5,700	2,000	7,700		
South Randolph	0	600	600	0	850	850	3,600	1,300	4,900	15,700	0.3
	0	300	300	0	390	390	1,600	600	2,400		
Ayers Brook	70	560	630	70	800	870	3,800	1,300	5,100	15,600	0.3
	50	300	350	30	390	420	2,100	600	2,700		
Gaysville	510	3,800	4,310	430	5,210	5,640	25,800	8,500	34,300	70,000	0.5
	450	2,940	3,390	330	4,030	4,360	20,300	6,500	26,800		
South Branch	1,070	2,290	3,360	1,470	3,160	4,630	20,200	7,000	27,200	38,700	0.7
	890	1,430	2,320	910	1,960	2,870	13,900	4,300	18,200		
Victory	1,300	4,900	6,200	2,230	8,850	11,080	37,200	16,600	53,800	20,100	2.7
	820	2,420	3,240	840	3,330	4,170	19,400	6,700	[illegible]		
Lyndonville	1,210	720	1,930	710	1,010	1,720	11,600	2,600	14,200	19,000	0.7
	980	500	1,480	470	670	1,140	8,900	1,700	10,600		

AT POSSIBLE FUTURE PLANTS

Reservoir	Increased peaking capacities-kilowatts Tributary	Main stem	Total	Increased output 1000 kilowatt hours Tributary	Main stem	Total	Annual values Peaking capacity	Output	Total	Annual cost of Storage	Ratio of value to cost
Massachusetts											
Easthampton	0	500	500	0	68,000	68,000	$3,000	$102,000	$105,000	$29,000	0.4
	0	250	250	0	34,000	34,000	1,500	51,000	52,500		
Fort Morrison	1,400	450	1,950	1,210	600	1,810	11,700	2,700	14,400	21,800	0.7
	900	250	1,150	650	330	980	6,900	1,500	8,400		
West Brookfield	1,920	620	2,440	3,170	780	3,950	14,600	5,900	20,500	55,100	0.4
	1,020	180	1,100	900	240	1,140	6,600	1,700	8,300		
Barre Falls	530	140	670	580	180	760	4,000	1,100	5,100	8,100	0.6
	430	140	570	430	140	570	3,400	900	4,300		
New Hampshire											
Honey Hill	0	960	960	0	1,340	1,340	5,800	2,000	7,800	20,600	0.4
	0	520	520	0	720	720	3,100	1,100	4,200		
Otter Brook	210	680	890	210	900	1,100	5,300	1,700	7,000	18,900	0.4
	150	400	550	120	540	660	3,300	800	4,100		
Claremont	300	3,000	3,800	380	4,010	4,390	19,800	6,600	26,400	38,000	0.7
	210	2,170	2,380	290	3,020	2,310	14,300	3,500	17,800		
West Canaan	840	2,110	2,950	1,710	4,300	6,010	17,700	9,000	26,700	13,800	1.9
	180	440	620	700	1,760	2,460	3,700	3,700	7,400		
Sugar Hill	460	5,670	6,130	370	7,700	8,070	36,800	12,100	48,900	55,000	0.9
	370	2,430	2,800	160	3,340	3,500	1,700	5,200	6,900		
Upper 15 Mile Falls	0	70,400	70,400	0	96,500	96,500	422,500	144,800	567,300	201,000	2.8
	0	37,200	37,200	0	50,900	50,900	222,300	76,400	298,700		
Vermont											
Williamsville	10,200	4,400	14,600	8,350	15,350	23,700	87,600	35,600	123,200	105,000	1.2
	6,580	4,400	10,980	3,610	5,960	65,800	65,600	14,400	80,000		
Cambridgeport	0	1,090	1,090	0	1,490	1,490	6,600	2,200	8,800	11,300	0.8
	0	640	640	0	860	860	3,800	1,300	5,100		
Brockway	0	2,900	2,900	0	3,970	3,970	17,400	6,000	23,400	48,000	0.5
	0	1,160	1,160	0	1,590	1,590	7,100	2,400	9,500		
Ludlow	2,800	4,350	7,150	3,550	6,000	9,550	42,900	14,300	56,300	26,900	2.1
	1,590	1,710	3,300	1,410	2,380	3,790	19,800	5,700	25,500		
North Hartland	0	2,400	2,400	0	3,340	3,340	14,400	5,200	19,600	47,000	0.5
	0	1,600	1,600	0	2,240	2,240	9,600	3,400	14,800		
South Tunbridge	2,370	2,620	4,990	1,800	3,600	5,400	30,000	8,100	38,100	47,600	0.8
	1,460	1,600	3,060	1,120	2,240	3,360	18,400	5,000	23,400		
South Randolph	910	1,020	1,930	710	1,430	2,140	11,600	3,200	14,800	15,700	[illegible]
	360	510	870	330	660	990	5,200	1,500	6,700		
Ayers Brook	840	950	1,890	740	1,340	2,080	11,400	3,100	14,500	15,600	[illegible]
	520	510	1,030	360	660	1,020	6,200	1,500	7,700		
Gaysville	5,710	6,410	12,120	4,820	8,780	13,600	73,700	20,400	94,100	70,000	[illegible]
	5,040	4,960	10,000	3,730	6,800	10,530	60,000	15,800	75,800		
South Branch	1,100	4,820	5,920	1,470	6,610	8,080	35,500	12,100	47,600	38,700	1.2
	890	[illegible]	[illegible]	910	4,070	4,960	23,200	7,500	30,700		
Victory	1,300	9,000	10,300	2,230	16,400	18,630	61,800	27,000	89,900	20,100	[illegible]
	820	4,480	5,300	840	6,150	6,990	31,800	10,500	42,300		
Lyndonville	1,210	1,330	2,540	710	1,840	2,550	15,200	2,700	17,900	19,000	
	900	920	1,900	470	1,230	1,700	11,400	2,500	14,900		

achusetts, and Union Village and North Springfield in Vermont, which were not further investigated for the reasons outlined in Paragraph 4 above. Benefits to conservation storage have been computed both for existing hydroelectric developments as listed in Table XXXII and for potential future developments as listed in Table XXXIII. The assumptions upon which these benefits were computed were:

a. That the potential increase in peaking capacity at existing downstream plants would be worth $6.00 per kilowatt. In almost every case involved, the realization of additional peaking capacity at existing plants would necessitate the installation of additional generating capacity.

b. That electrical energy generated at existing plants would have a value of 1.5 mills per kilowatt hour.

c. That storage capacity provided at flood control sites would be utilized 100 percent once each year.

d. That water would be utilized at a load factor of 25 percent.

6. GENERAL CONSIDERATIONS. - No detailed study of the possible market for hydroelectric power was made. There are attractive hydroelectric sites in the basin, notably the Upper Fifteen Mile Falls site, which are owned by utility corporations, which have not been developed. On the other hand, new steam generating capacity has been constructed within the general region recently, and construction is about to be initiated on a 40,000-kilowatt steam generating station at Providence, Rhode Island. The chief value of water power in the New England region is to absorb peak load, and at present there is sufficient hydroelectric generating capacity available to carry the peak of the existing total load. The base load is carried more economically by steam stations. In general, not until the total load for the region has materially increased, thus providing a greater total peak load, will it be attractive to develop additional hydroelectric power.